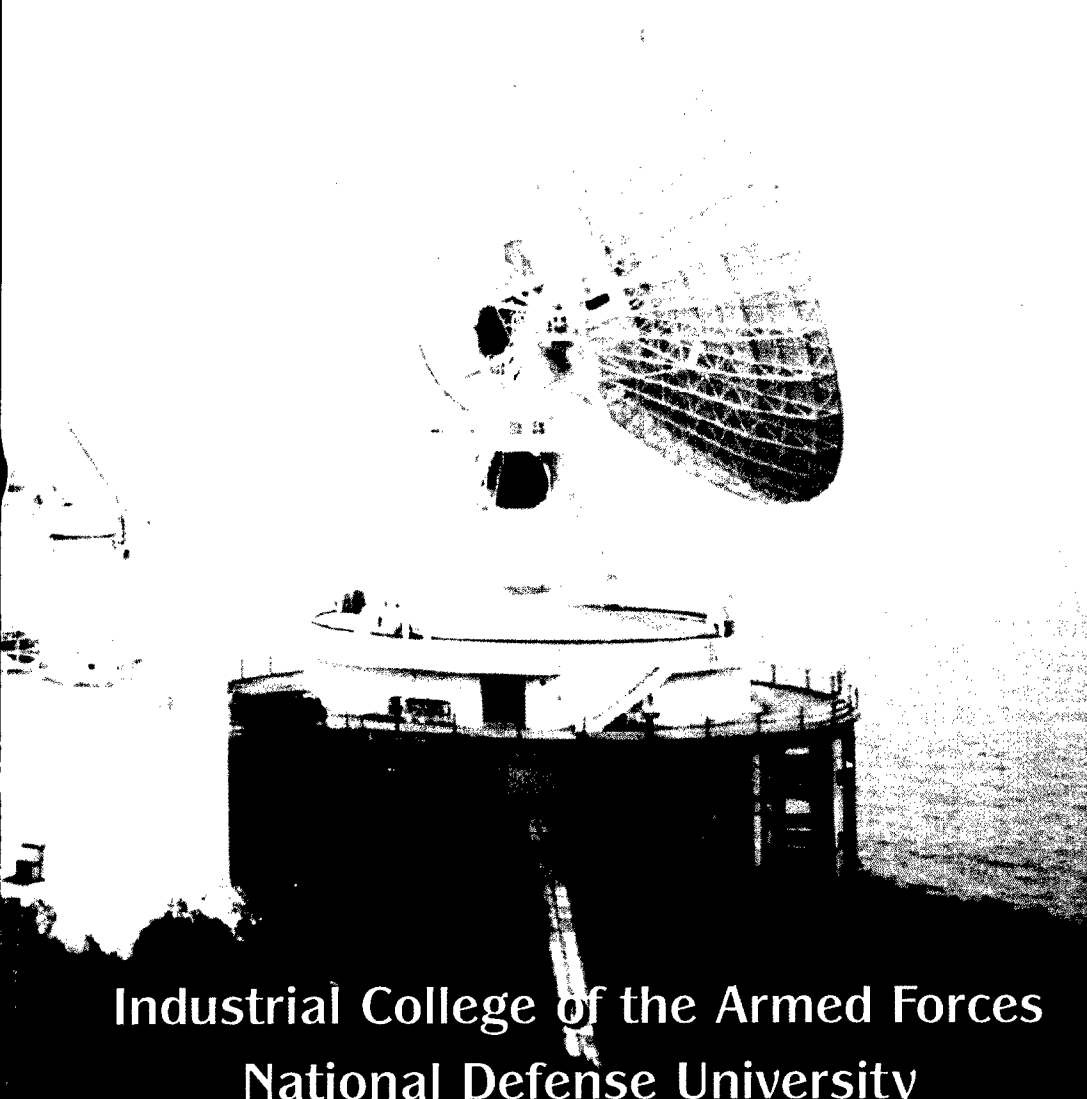


In
TOUCH
with
INDUSTRY
ICAF Industry Studies 1998



Industrial College of the Armed Forces
National Defense University

IN TOUCH WITH INDUSTRY: ICAF INDUSTRY STUDIES 1998



19990405 010

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1998

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The industry studies program is part of the College's continuing commitment to "keep in touch with industry"—a charge made by Bernard Baruch at its founding almost 75 years ago. The following chapters provide an assessment of the condition and outlook of 18 industry sectors considered vital to the nation's security. While the senior civilian and military student authors are not experts in each industrial sector, they do bring a wealth of practitioner and professional knowledge to their studies including technical, operational, acquisition and logistics support experience.

Industry field studies were carried out both domestically and internationally to allow our students to conduct in-depth examinations of selected industrial sectors to assess each sector's ability to support the national security strategy within a global context. The resulting reports organized here as chapters are offered as part of the continuing public policy debate over the health and future of the defense industrial base in particular and the total industrial and productive base in general. Additionally this book is published in an effort to maintain an open dialogue with the many companies and agencies we visit worldwide.

This year's study included, for the first time, a look at the services industry. The study's focus was directed largely at those companies that support defense operations. Next academic year, the focus will be expanded to the total industrial base and address the impact of the apparently increasing shift to outsourcing on productivity, capacity and competitive position.

Suggestions for other areas of study or comments should be directed to the editor. In closing, I would like to thank all those companies and agencies which have so generously shared their time and knowledge with our students.

Richard L. Engel
Major General, U.S. Air Force
Commandant

ADVANCED MANUFACTURING

ABSTRACT

The focus of advanced manufacturing is not on product lines, but on the processes by which products are built. Advanced manufacturing is the methodology behind the current revolution in manufacturing affairs that is redistributing comparative advantage worldwide. Manufacturing has fundamentally changed with the arrival of global competition. This is evidenced by those enterprises capable of distributing value chain production worldwide and reducing costs by exploiting automation and information integration. The US cannot and should not attempt to compete on a labor cost basis. Our comparative advantage resides in technological and process innovations that boost productivity and make advanced manufacturing possible. Since manufacturing underpins all aspects of the economy, its importance to national defense should not be underestimated. A well thought out and consistent government policy on advanced manufacturing can do much to nurture and extend America's competitive advantage in this sector.

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PLACES VISITED

Domestic

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Best Manufacturing Practices Center of Excellence, College Park, MD
Cincinnati Milacron, Cincinnati, OH
Dept. of State National Foreign Affairs Training Center, Arlington, VA
General Dynamics Land Systems Division, Lima OH
General Motors Assembly Plant, Wilmington, DE
General Motors Corporation, Warren, MI
Honda of America Manufacturing, Inc., Anna, OH
Mutual Tool & Die, Dayton, OH
Northrop Grumman Corporation, Baltimore, MD
TS Trim Industries, Canal Winchester, OH
University of Maryland, College Park, MD
W. L. Gore & Associates, Newark, DE

International

American Consulate General, Guangzhou, China
Conhui Electronics Company, Huizhou, China
Guangdong Provincial Economic Commission, Guangzhou, China
Owens Corning Fiberglas, Guangzhou, China
Southern Telecommunication Development, Huizhou, China
Warner Lambert, Guangzhou, China
American Chamber of Commerce, Hong Kong
American Consulate General, Hong Kong
China Aerospace International, Hong Kong
Hong Kong Trade Development Council, Hong Kong
Hong Kong University of Science and Technology, Hong Kong
Li & Fung Group (Trading) Ltd., Kowloon, Hong Kong
Aisin Seiki Company, Ltd., Aichi, Japan
American Consulate General, Nagoya, Japan
Mitsubishi Heavy Industries, Ltd., Aerospace Systems, Nagoya, Japan
NGK Insulators, Ltd., Nagoya Japan
Toyota Commemorative Museum, Nagoya, Japan
Toyota Motor Corporation, Aichi, Japan
Yamazaki-Mazak Trading Corporation, Aichi-Pref, Japan

INTRODUCTION

The unique role of manufacturing in the economic health of the US is neither fully appreciated nor understood. As long as the fruits of the industrial revolution and its later manifestations continue to show up on store display shelves, the average citizen does not often stop to consider what domestic manufacturing means for the country's future. Manufacturing represents 20-23% of the Gross Domestic Product (GDP) and has remained stable as a percentage of the GDP since the late 1940s (Manufacturing Institute). At approximately \$1.5 trillion of the GDP, manufacturing in absolute dollar terms is less than service industries but still dwarfs all historical precedents. The US is a manufacturing and service industry country—one in which the manufacturing sector has increasingly come under pressure by foreign competition and domestic neglect.

Manufacturing continues to be an important engine of the national economy. US Department of Commerce statistics show that for every \$1.00 change in manufacturing output, there is a \$2.30 change in total output in the national economy. Manufacturing is responsible for between one-third to one-half of all economic growth in the US (US Bureau of Census, 1993). Manufacturing employs 75% of all scientists and engineers and conducts 91% of all business research and development. Seventeen percent of the country's workforce or 21 million people are employed in this sector. For every 100 jobs created in manufacturing, another 60 jobs are created in other industrial sectors (Manufacturing Institute).

This report assesses advanced manufacturing at the national strategic level. It addresses domestic shortcomings and global challenges and presents recommendations that can be implemented at the national level to maintain a viable American industrial base.

ADVANCED MANUFACTURING DEFINED

A reason for the resurgence of the American manufacturing sector has been the relentless drive to achieve a competitive advantage through higher levels of productivity and improved customer service. Whether termed just-in-time, advanced manufacturing, lean thinking, or manufacturing flexibility, the elimination of waste from the value chain, and a drive to push the limits of technology are the dominant ideas in state of the art manufacturing. Advanced manufacturing consists of the "hard" improvements made in manufacturing machinery and technology

and the "soft" improvements of waste reduction, resource management, statistical control, and core competencies. This blending of technological innovation and process control has led to an increase in productivity that has allowed American manufacturers to compete successfully worldwide.

Manufacturing is a process of applying correct business practices that result in the production of the right product, in the right quantity, at the right time. Two new elements, time and distance compression, have been added to traditional business concerns. Time compression has placed a premium on the ability of businesses to respond quickly and correctly before their competitors dominate new markets. Distance compression has resulted in the whole world becoming potential sources of supply and competition. This is particularly true in the global pressure to reduce wages to achieve a cost advantage. Advancements in transportation and information technology are but two manifestations of this new reality.

Two specific elements must be present in a manufacturing concern before it can be termed advanced. The first of these is the use of advanced technology for precision control of the manufacturing process. This creates a uniform and consistent quality product. Technologically advanced machinery is often capable of multiple uses and of being quickly reconfigured for similar products. This flexible response to customer demands allows a manufacturer to respond to a wider range of conditions without making additional capital investments. The second element of advanced manufacturing is the application of advanced processes used throughout the value chain to reduce costs. Management and labor review processes for continuous improvement. Waste and the inefficient use of resources are examined in detail to determine how they can be eliminated. A highly trained and motivated work force acts as a multiplier for management efforts. Also included in this process review is what can best be termed the human elements of management.

When placed on different axes, these two major elements result in a matrix into which comparative manufacturing concerns can be placed. The resultant matrix quadrants are depicted in Figure 1. In the lower left corner are those firms that use more traditional technology and manufacturing practices. These traditional manufacturers rely on lower labor wages and economies of scale to reduce costs but are often at a competitive disadvantage with advanced manufacturers. While capable of producing an effective product, these firms seldom achieve the efficiencies that propel them into the ranks of world class producers.

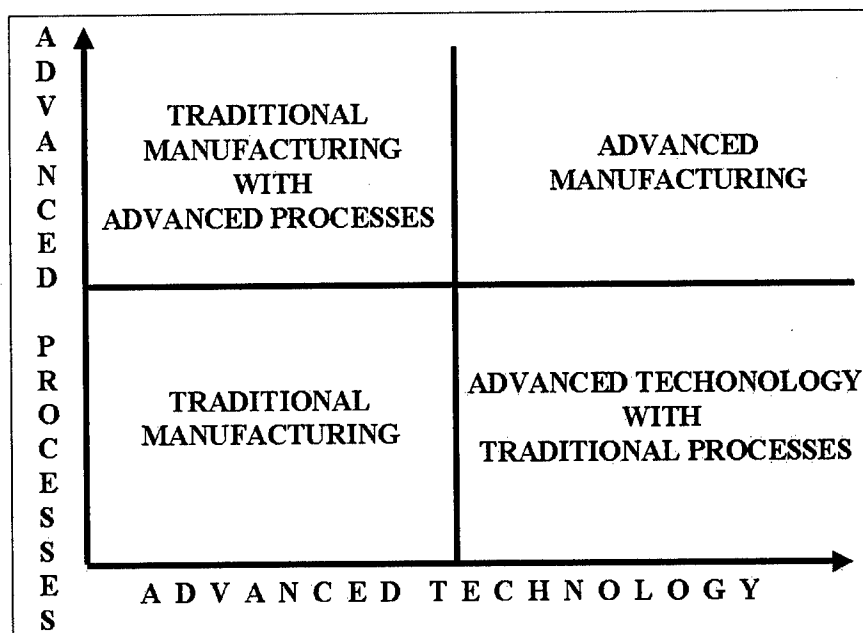


Figure 1, Manufacturing Matrix

Observations and predictions of behavior can be made for the upper left-hand quadrant (Traditional Manufacturing /Advanced Processes) and the lower right-hand quadrant (Advanced Technology/Traditional Processes). In Traditional Manufacturing/Advanced Process firms, the most is made of existing resources to obtain a market niche position. For Advanced Technology/Traditional Process manufacturers, many companies have mistaken advanced technology as the goal that will deliver the competitive edge desired. Often, additional efficiency is obtained, but at a burdensome infrastructure cost for the organization. These firms can continue to be efficient producers. However, capital limitations frequently cause them to be eventually overwhelmed by larger and more diversified competitors.

Those manufacturers that use advanced technology and advanced processes can be defined as advanced manufacturers. These firms create a competitive advantage by systematically reducing costs and improving market response time.

The study group visited organizations that represented all quadrants to identify applicable lessons for enhancing the growth of advanced manufacturing in the US. The group concentrated on the lessons applicable to pulling more manufacturers into the advanced manufacturing quadrant.

CURRENT CONDITION

To analyze the current condition, the group looked at the following areas: diffusion and adoption of technology, profitability, small business impact and vertical integration, productivity, synergistic effects of advanced technology, labor-management relations, and government and industry research and development (R&D).

Diffusion and Adoption of Technology

The current adoption of advanced manufacturing technology across the full spectrum of manufacturing is uneven. New, advanced manufacturing technologies typically take 5 years to penetrate 25% of major firms engaged in one manufacturing sector. The slow introduction of advanced flexible systems may be related to poor rates of return experienced by some companies. Companies making these investments anticipate returns of greater than 25%, but have averaged closer to 10%. This is well below the profit contribution of other innovations. Another issue is that many firms fail to make an adequate evaluation of the potential impact of advanced manufacturing on business operations or the bottom line (Mansfield, pp. 149-156).

Despite the issues discussed above, the use of new advanced technologies has been positively related to plant performance as measured in sales growth, profit margin, and market share (McGuckin, Streitwieser, and Doms, pp. 28-29). The growth and adoption of advanced techniques continue unabated. According to the Manufacturing Institute, in a recent survey of manufacturers, a majority employed nine advanced technologies ranging from Computer Aided Design (CAD) to Computer Aided Manufacturing (CAM). The same survey showed that a majority of manufacturers also employed six process technologies ranging from manufacturing cells to just-in-time inventory techniques. Whether the diffusion of advanced manufacturing technology can be sustained and translated into future productivity gains to maintain the current momentum is unclear. The transition of new technology to the shop floor is not always a smooth process; ultimately, it is on the shop floor that new technology is proven successful or not.

Profitability

Despite the importance of manufacturing to the national economy, manufacturing profitability has suffered in the last 40 years. Since the mid-1960s manufacturing profits have been on a downward trend with

only a few minor upturns. Manufacturing profits averaged 9.3% in the 1960s, 8.4% in the 1970s, and 6.8% in the 1980s. This was followed by the depressingly bad year of 1992 where profits averaged an all time low of only 1.0%. Manufacturing associations have ascribed this decline to a period of slow growth in the US economy and increased international competition. Since 1992, an upturn in the economy and major restructuring and cost control have steadily led to increased profits. Incomplete data for the 1990s shows profits averaging 4.1% (Manufacturing Institute). Third quarter 1997 seasonally adjusted profits for the manufacturing sector should come close to 6.3% per dollar of sales according to US government surveys (U.S Bureau of the Census, 1997).

Industry benchmarks across several manufacturing sectors show an extraordinary turn around. For example, the profits in the fabricated metals industry now average 3.7% for the corporate fiscal year that ended in 1996. The best company in this class averaged a profit margin of 12.12%. The auto industry (excluding the Big Three [Ford, General Motors, and Chrysler]) averaged 3.68% profit with the best manufacturer posting a rate of 5.85%. Of the Big Three, Chrysler Corporation, who many had consigned to bankruptcy in the early 1980s, achieved the best profit (5.9%). In the electronic industry profits are averaging a robust 7.78%. The best manufacturer in this group averaged an astonishing 22.01% profit rate.

Despite the apparent health of the manufacturing sector, all companies have not shared this resurgence; nor have companies within a particular industrial sector shared it. Profits are important because many companies self-finance recapitalization needed for market expansion or productivity increases. Marginal profits mean fewer manufacturers will be able to compete effectively over the long term.

Small Business Impact and Vertical Integration

It seems that only large firms can make the considerable capital investments in advanced manufacturing machinery needed for efficiencies. The reality of the situation is much more complex. The US is the world's largest consumer of new machine tools, consuming 20% of global output (American Machine Tools, p. F4). The bulk of this growth in orders is coming from smaller machine shops attempting to profit from outsourcing of functions by large companies. Congress has aided this trend by funding the Small Business Technology Transfer Program. This program allows small businesses to collaborate with nonprofit research institutions to capitalize on innovation and bring new products

to market (Kladiva, p. 7). Another federal program aimed at small and medium-sized manufacturers is the Manufacturing Extension Partnership, which helps to enhance technology diffusion (US Department of Commerce, 1997, p. 1).

Some small businesses that have become efficient are being vertically integrated into a prime manufacturer's value chain, thus becoming almost indistinguishable from their prime vendor. This trend is already apparent in many Japanese manufacturers both in the US and abroad. Second and third tier suppliers wishing to take advantage of economies of scale are facing pressures from prime manufacturers demanding frequent price reductions and just-in-time deliveries of component items. Since advanced manufacturing pushes inventories down the supply chain, suppliers are being forced either to hold larger inventories of finished goods or to purchase smaller quantities of raw materials (Polito, p. 6). As the need for greater flexibility increases for the prime manufacturer, second and third tier suppliers are squeezed to reduce costs while increasing risk.

Productivity

The manufacturing sector is large and diversified. It is difficult to ascribe its current rebound to only one or two factors. Productivity gains by using advanced manufacturing equipment and technologies are an important factor. As of 1995, manufacturing productivity in the US had grown at a rate of 3.25% annually, while Germany had averaged only 1.6% annually and Japan had experienced negligible growth. Manufacturing growth should accelerate in the next few years, as the cost of technology for such things as embedded logic and circuits becomes cheaper. However, productivity gains are dependent on the availability of machines and capital needed to purchase them. Many manufacturing plants in the US employ old machinery. Within the last 3 years, more than 60% of US machine tools were 11 years old or older. (Manufacturing Institute). The group observed during its cursory evaluation that the largest Japanese machine tool manufacturer was more heavily capitalized with newer equipment than was the largest American machine tool firm.

Synergistic Effects of Advanced Technology

Studies show that an investment in advanced manufacturing technology has synergetic effects on management. This enhances many process attributes of advanced manufacturing resulting in even greater

productivity (McGuckin, et al., p 29.). It is apparent from the business literature that an investment in technology alone does not make a firm competitive. A manufacturing firm must also create a culture that encourages a quest for excellence and continuous process improvement. One of the Big Three automakers invested nearly \$40 billion in new technology without a clear vision about what improvement automation was to accomplish. It gained little or no productivity improvement for this huge investment (Lau, p. 14). However, successful companies are more likely to use advanced technology than poor performers. One of the primary revelations concerning studies of companies using advanced manufacturing systems is that the final flexibility of the plant was more dependent on its people than any technology employed alone (Upton, p. 75). Advanced manufacturing can benefit quality, inventory, and customer satisfaction in a way that may not always be immediately quantifiable but that does become apparent over time. An additional benefit appears to be market sustainability where advanced manufacturing is transformed into a competitive advantage.

Labor-Management Relations

A survey of the best manufacturing plants indicated that to achieve substantial productivity gains it was necessary for all employees, including senior and middle management to have total commitment. Senior management sets the stage for success by creating and implementing the strategic vision necessary to obtain positive results (Verespej, p. 3). Nonmanagement personnel were tasked with task execution, but were more effective once they understood the company's vision. Many advanced manufacturing organizations are also lean organizations with flat and highly interactive hierarchies. Flat, team-based organizational structures help to facilitate and catalyze better communication and enhanced responsiveness to competitive pressures.

Failure to achieve expected business outputs highlights the need to abandon traditional confrontation policies practiced by organized labor and management. Advanced manufacturing may induce a change in labor-management relationships. Conversely, a climate of teamwork and labor-management cooperation may be more receptive to adopting advanced manufacturing technology, processes, and culture as a solution.

Government and Industry Research and Development

Significant R&D investment is a principal reason for US dominance and continuing significant lead in high technology manufacturing.

Government and private industry have been instrumental in funding this research. The fiscal year 1998 US federal budget contains proposals for a total of \$72 billion in R&D programs. This is a modest increase over the previous year, but it is concentrated predominately in military applications. With such a concentration, the R&D opportunity for commercial products is doubtful. A small portion of the nondefense government investment in R&D (\$60 million in 1998) will be spent in support of small business technology transfers. While the goal has been to motivate firms to invest in areas that they might not ordinarily undertake due to risk or cost, the amounts are inconsequential. The industry has contributed greater value to R&D; private industry invests about \$100 billion per year. However, downsizing and cost cutting pressures have created a negative R&D investment trend.

While direct government and industry R&D funding is projected to decline in real terms, a web of government, industry, academia, and consortia agencies has emerged dedicated to ensuring the continued dissemination of competitive manufacturing techniques. One of the largest such efforts is the Next Generation Manufacturing Project of 500 members. However, the flow-down or insertion of high-technology manufacturing to commercial business applications is not linked as strongly as it could be. The number of government regulations that must be followed to participate in, or to obtain funding for research is often frustrating. This government bureaucracy is ultimately counterproductive if quality firms do not participate.

CHALLENGES

In the current global economic environment, the US manufacturing sector has emerged as the nation's productivity leader. It has melded machine technology, information technology, and process changes into a coherent near-term strategy to increase profitability. However, this advantage is tenuous since challenges and weaknesses still exist that will require vigilance and a measured strategic response. Each manufacturer, large and small, operates in a unique environment, but faces two common forces: heightened customer demand and expectations and rapidly accelerating technological change. These forces shape three broad challenges that the manufacturing sector will face in the next few years—*balance, agility, and competitive advantage*.

Common Force of Heightened Customer Demand and Expectations

Heightened customer demand and expectations have led to insistence on high standards of product quality and massive proliferation of product types. The phenomenon of ever increasing numbers of alternative product designs can be seen in the automobile industry, machine tool industry, electronics, music, or any other commercial endeavor. It is likely that the number of product features and unique product choices will continue to expand. This is due in part to the increased competitiveness of the global market that makes the goods of worldwide manufacturing sectors available to the global consumer. Also, the youthful demographic nature of the new consumer sometimes called the "global teenager" is a contributor. The global teenager is interested in diversity of choice to a greater degree than previous generations. This demand for product differentiation has important long-term implications for advanced manufacturing. Competitive manufacturers reacting to this force will court diverse market demands with optional product features that tend to differentiate their product from their competitor's product.

Manufacturing is evolving from its medieval crafts trade roots. Heightened customer demands and expectations blended with rapidly accelerating technological change are collectively advancing the face of manufacturing as we know it. Table 1 compares the evolutionary steps of manufacturing improvements from the beginning of the industrial revolution to present-day and beyond (National Science and Technology Council, p. 3).

Table 1: Evolution of Manufacturing Paradigms

	Craftsmen And Custom	Mass Production	Automated Production	"Next Generation" Systems
Timeframe	Up to Present	1800s to Present	1950s to Present	1990s and Beyond
Lot Sizes	Small	Very Large	Moderate	Small
Unit Costs	High	Low	Moderate	Low
Quality	Variable	Good	Good	Excellent
Delivery Times	Long	Long	Moderate	Short
Flexibility	High	Low	Moderate	High
Education and Training	Individual Apprentice	Limited	Moderate	High, Continuous
Environmental Consciousness	Low	Low	Moderate	High

Toyota is a good example of a company reacting to massive product proliferation. Integrated on a single line at its Takaoka Plant, Toyota produces three entirely different models of automobiles. Their manufacturing technologies and processes are flexible enough to accommodate left and right side drive systems for export and for domestic Japanese consumption. Toyota is not content that its existing product line has the necessary appeal to younger generation Japanese, so it has embarked on an innovative "virtual venture" for designing a new automobile. Toyota's "virtual venture" is led exclusively by its younger employees in an effort to tap into the creativity and marketing savvy of the next generation of auto designers.

Aisin, a major parts supplier to the international automotive industry, developed unique processes for design-to-manufacture and material handling in order to efficiently produce more than five million assemblies per year needed by their many customers. They are able to achieve large economies of scale even for low volume products by sandwiching small lots between larger lots.

Common Force of Rapidly Accelerating Technological Change

The second inevitable driving force common to all manufacturing endeavors is the rapidly accelerating technological change brought on by modern information technology. Advancements in computer and communication technology provide bandwidth-on-demand and cheap prices for global connectivity. These developments will make information transfer the great facilitator of the advanced manufacturing revolution.

The combination of these two immutable forces, heightened customer demand and expectations and rapidly accelerating technological change, are complementary. The first provides the demand for flexible manufacturing methods of mass customization. The second provides the means to facilitate the revolution in manufacturing affairs through information technology that can manage a wide diversity of product designs and the means to change rapidly to new customer requirements.

Technological advancement has enabled "mass customization," a term first coined by Stanley M. Davis in *Future Perfect* in an attempt to illustrate the paradigm shift away from mass production. An environment of rapid change characterizes this new paradigm where competitive advantage goes to the firms that achieve the oxymoron of mass customization—"the production and distribution of *customized* goods and services on a *mass* basis" (Pine, p. x). A simple example of

this is Pizza Hut Delivery where you call in your pizza order, *customized* the way you like it, produced to order (on a *mass* basis, but in economic quantities of one) and rapidly delivered to your door. For more complex goods such as an automobile, agile/flexible manufacturing systems and processes could allow one to custom order an automobile and have it economically produced and delivered within just a few days.

Challenge of Balance: Technology at the Right Place and Time

Technological advances and the widespread use and application of information processing underlie much of the current success and productivity of the US manufacturing sector. Competitive pressure to lower costs and increase productivity influences decisions to automate. Unfortunately, this frequently results in an increase in technology and machinery to the detriment of human participation. This has been succinctly expressed in the phrase "lights out factory" in which machines do all the manufacturing without any human involvement.

Efficiency, productivity, or competitive advantage is achieved only when the right balance is struck between technology, processes, and people. Humans can offer insights into processes where cost savings can occur—machines can't. An investment in automation is expensive. If not made wisely, it can do more to damage the corporate bottom line and productivity than a worst-case labor strike.

Linked to the need to field new productive technology, R&D is an investment in the future. US manufacturers continue to make considerable investment in R&D but the focus has become short term with an orientation to new product development. Research to promote technical advances and innovation for long term development of advanced manufacturing systems has recently declined. Research in process improvement too often takes a back seat to technology research. Present government efforts to help have often been made more difficult by bureaucratic rules and regulations.

The current approach to automation and information systems is also problematic. It can best be described as ad-hoc, lacking the vision and roadmap for an integrated national information system architecture. Existing data environments and network protocols do not support collaboration. Neither do they assist in the creation of "virtual corporations" which leverage managerial ability and information to create products worldwide. A robust national information infrastructure is needed to establish standards for interoperability and compatibility. This will link modern manufacturing applications together with advancing machine technology to help achieve increased productivity.

Challenge of Agility: A Cultural Revolution

Agile/flexible manufacturing is the ability to quickly change a broad range of operating characteristics related to manufacturing processes, product design, and management structure. This focus takes advantage of new manufacturing technologies, facilitates a timely response to unanticipated market opportunities, and represents a major shift in the way most US companies do business.

Agile/flexible manufacturing requires an infusion of next generation technologies on the manufacturing floor that goes beyond just buying smarter robots. It also requires an extensive information infrastructure; agile suppliers connected via an enterprise web and linked by a robust, multimode transportation infrastructure; a learning organization culture of empowered, integrated design teams; and highly skilled and technically competent workers on the shop floor. With few exceptions, US firms are not yet implementing strategies to achieve these attributes.

Perhaps the hardest challenge for a company to overcome is the cultural change needed to become agile/flexible in manufacturing. Companies must change the way they organize and manage people. Since the early days of mass production, our nation has embraced a "Tayloristic" organizational culture of specialized labor. This separation of *thinking* and *doing* served the early days of mass production, but is an absolute impediment to achieving agile/flexible manufacturing.

In an agile/flexible-manufacturing factory, workers must be thinkers and doers—highly skilled, team-based, and empowered. Every manufacturer the group visited adamantly elevated the importance of people over their most advanced technology.

Many decades of "unions versus management" adversarial culture based on specialized divisions of a low-skilled labor force must be reversed. It is important to mention that not all union-management relationships observed were adversarial. For example, yielding to cost pressures, General Motors had decided to close their Wilmington, Delaware Assembly Plant. This prompted management and the union to team effectively to successfully transition their assembly plant to a new production model.

US labor union policies that insist on "last hired, first fired" contribute to the "graying" of the manufacturing workforce and portend serious implications for the ability to grow a technically experienced workforce. US manufacturers must adopt strategies that respond to the demographics of an aging and ethnically diverse labor pool.

The nation's primary and secondary school systems are not supplying a workforce capable of assuming the technical duties of an advanced

manufacturing workplace. Four in ten business executives say that they can't modernize their equipment because their workers lack appropriate skills (NAFCAM, p. 32). Most manufacturers cited requirements to provide training in basic reading and math before new employees can assume manufacturing duties. The lack of skilled labor was also voiced by Chinese and Japanese manufacturers as a problem.

Challenge of Competitive Advantage: Continuous Improvement

The waste that was easily identified in the manufacturing process in the past and rectified with advanced manufacturing techniques will more likely be "marbled" or interspersed throughout the manufacturing process in the future. Process improvement emerges as a nucleus of focus to nurture advanced manufacturing practices. A commitment to action is needed, followed by a mechanism to identify wasteful, non-value-added activity. The Japanese ushered the term *Kaizen* into the common vernacular of manufacturers as the key to efficiency. The *Kaizen* process provides a level of scrutiny and transparency that are essential to improving manufacturing processes. Improvement activities must be narrowly focused with clear, measurable goals. Unfortunately, all too often US manufacturers decide to fire workers or close plants without first trying for the benefit of a *Kaizen* process.

Another area for continuous improvement is in updating technologies along with processes. For example, the nation that leads in tooling its factories to complement process improvements will hold a distinctive competitive advantage. Currently, America is experiencing growth in both domestic and export machine tool markets. However, current American production accounts for only about 11% of the world's output. Imports outpace exports in the US by a factor of three to one (American Machine Tools, p. F4).

Most manufacturers can't afford the long-term capital investments necessary to tip the scales of competitive advantage in favor of the US. Among these are investments in technological advances, manufacturing infrastructure, and training to bring unskilled workers up to the required level. Many US machine tool manufacturers are small family-owned businesses. They struggle to retain market share and rarely develop first-to-market new technology. The government can either provide the funding, or encourage private investment through tax credits.

OUTLOOK

Four driving forces will dominate the future of advanced manufacturing. They are heightened customer demand and expectations, rapidly accelerating technological change, globalization versus protectionism, and the uncertainty pertaining to the level of integration that can be expected between defense and commercial sectors. Two of these forces—heightened customer demand and expectations and rapidly accelerating technological change—are inevitable and were discussed in the Challenges section of this report. To extrapolate from the resultant trends of these first two forces, technological advancements will continue to reduce direct human involvement in the US manufacturing sector. This will increase the productivity of the workforce. Intelligent human interaction will be more crucial for those hands-on processes that cannot be automated. Clearly, the educated worker will be one of the keys to the future of advanced manufacturing.

Furthermore, technological changes will alter the way products are built. A good example of an interim step in this direction is the automation of composite technology. Unlike traditional metalworking techniques, this technology builds complex structures by layering fibers and laminates to achieve the desired properties. By 2020, manufacturing techniques may further yield to nanotechnology production methods. Using nanotechnology, product features will be built up from the molecular structure level, rather than cut down from a block of homogeneous material. This would truly represent a fundamental manufacturing paradigm shift.

The impact of the two other forces is more difficult to assess. The first of these is a “globalization vs. protectionism” sentiment regarding national markets. The second is the uncertainty pertaining to the level of integration that can be expected between the defense and commercial sectors. The interaction of all these forces could change the future environment for advanced manufacturing. Although the forces do not predict the future with any clarity, what is implied may help government decide what its roles and goals should be in maintaining a viable industrial base.

Globalization vs. Protectionism

Information technology provides connectivity and coordination tools that enable the dispersion of manufacturing tasks worldwide. Aside from the obvious advantages of enhancing internal coordination within a manufacturing firm, information technology enables new strategies for

international competitive advantage that rely on global knowledge supply chains. One of these strategies is the "virtual corporation." It leverages adaptive, responsive information systems that rapidly reconfigure to accommodate the formation of new organizations. The virtual corporation is a network of firms configured to provide a service or product. In its most competitive scheme, this network is global. As companies become more international and less identifiable with any particular nation, there will be no political boundaries for technology and process management. Therefore, the policy trend toward increased openness of global trade enhances the benefits of advanced manufacturing processes. Consequently, if the trend toward increased globalization continues, firms exploiting the benefits of advanced manufacturing will become more profitable.

Thriving in a global marketplace, the Japanese firm of Yamizaki-Mazak Trading Corporation, from now on called Mazak, is a dominant force in the mid-to-high range machine tool industry. Despite the downturn in the Asian-Pacific economies, Mazak has grown 25-29% per year for the past 4 years ending in 1997. One reason for this continuous growth is the demand from the automobile and aircraft industries for increased machine tool productivity. More importantly, Mazak's market is globally diversified. Sales are allocated among North American, European, Japanese, and other regions according to a 30:30:30:10 market ratio respectively. This global diversity enhances Mazak's security against regional economic fluctuations.

American firms also benefit from strategies of international diversification. Consequently, US government policy should be geared to continue the trend toward free international markets and economic globalization from policies promoted by the World Trade Organization and General Agreements on Tariffs and Trade. In the future, US international leadership may be necessary to ward off protectionist tendencies that could come as a backlash to the Asian financial crisis or because of greater economic integration within the European Union.

Current US strategic trade control policies present several challenges to the American manufacturing sector. Manufacturers acknowledge their responsibility to ensure that US national security interests are protected, but more than one cited US trade policy as a barrier to their ability to be fully competitive in international markets. They noted that a US decision to deny export of controlled technology kills a market for a US product, technology development, and profit. In the current competitive environment, another country will quickly fill the void and provide the needed technology.

Separate Defense Sector vs. Integrated Defense-Commercial Sector

The next uncertainty concerns the relationship between the defense and commercial industrial sectors. Can the defense sector restructure to gain from the efficiencies of a globally competitive commercial sector?

The current trend in the US shows consolidation of defense business into a few major companies. Except for Boeing, the other major defense firms (Lockheed Martin, Raytheon, and Northrop-Grumman) have few commercial business interests compared to their military contracts. If such a trend continues, it is unclear if the revolution in manufacturing affairs so evident in the commercial sector will spill over into the defense industrial base. For instance, commercial industry typically responds to new product cycles of electronic improvement every 6 to 18 months, whereas the typical weapon development cycle is 16.5 years (Gansler, p. 10).

A defense-unique industrial base no longer meets the nation's needs. Significant restructuring is still in order to ensure an efficient and competitive industry. The group observed resources being committed to defense manufacturing facilities operating well below capacity that should be considered for conversion to dual-use. Dual-use-by-design is one agile/flexible manufacturing strategy that provides an opportunity for the defense industrial base to respond to post-Cold War threat and budget environments. An agile/flexible manufacturing strategy facilitates a transition to dual-use so that the commercial sector can keep the industrial base "warm" and ready to mobilize for increased military production in time of crisis. An agile/flexible manufacturer can produce small lot quantities more economically—in the ideal sense, an economic quantity of one. In a dual-use line, a defense component can be produced on the same production line as a similar commercial product. This manufacturing approach is currently being prototyped in the Military Products from Commercial Lines Program to produce two communication, navigation, and identification modules compatible with the Air Force F-22 Raptor and the Army RAH-66 Comanche helicopter. These components have been designed for production on a commercial automotive electronics manufacturing line (Kinsella and Heberling, p. 36). A dual-use-by-design strategy will allow the nation to take advantage of technology, products, and processes that have proven to be more competitive and efficient in the commercial sector.

Instead of dedicated defense companies, Japan has industrial conglomerates that have defense business as one of their activities. The Japanese aerospace firm Mitsubishi Heavy Industries (MHI) is an example of a company that is predominately commercial, yet it is the

largest defense contractor in Japan. In 1996, MHI handled nearly 40% of the total Japanese defense procurement budget; yet, defense accounts for only about 20% of MHI's turnover (*The Economist*, p. 14). In their Oye plant, MHI manufactures parts for commercial and military products under the same roof.

The ideal integration of commercial and defense manufacturing would permit military products to be built on the same production line. Presently, this is hard to do in practice, because some military equipment is built to specifications that are more demanding and with techniques not necessarily used in the commercial sector. For instance, wing structure for the Japanese F-2 (FSX) fighter uses a variety of composite material processes that are not used for the aluminum parts MHI builds for the Boeing 767 and 777. In other cases, MHI builds military aircraft such as the MH-60 Blackhawk and F-15J Eagle under license with American manufacturers and enforces the legacy military standards invoked by the US government on the original equipment manufacturer.

Structurally, the Japanese defense industry is in a much better position to leverage the concept of dual-use-by-design because of the predominately commercial emphasis already resident in firms doing defense business in Japan. It will be interesting to watch for increased integration in military and commercial manufacturing at Mitsubishi in the future. The US government should consider policy to better integrate American commercial and defense industry.

GOVERNMENT GOALS AND ROLE

The federal government is already involved in several aspects of advanced manufacturing but these are often piecemeal and without any consistent direction. Government's role should be to enhance the competitiveness of the national manufacturing industrial base by the intelligent and selective use of market forces—not through protectionist policies. The defense industrial base for the most part is a subset of the larger commercial industrial base. A healthy and thriving defense industrial base requires a healthy commercial base. Government must aim at the larger commercial sector to ensure that the specialized defense sector is appropriately nurtured. Government policies must consider the critical uncertainties affecting the future of advanced manufacturing to enhance the competitiveness of American corporations in the global economy thereby preserving an American defense industrial base. The federal government should act upon the following policies.

- *Encourage increased basic R&D expenditures.* R&D represents a down payment on the future. Industrial nations cannot avoid its responsibility to pay for R&D and still hope to be leaders in advanced manufacturing. For instance, basic research in molecular properties and nanotechnologies hold promise for establishing bridgeheads in future markets beyond the narrow time scale of business R&D. Only government can provide the long view necessary to make these possibilities a reality. Spending should be increased for commercial R&D.
- *Encourage business investment in people and processes.* People are the key to flexible manufacturing systems. Business labor practices often run contrary to those needed to achieve the synergy necessary to produce efficiencies. Companies and labor organizations that agree to a productive partnership rather than an antagonistic relationship should be encouraged and rewarded. Additionally, those companies that partner with schools to train personnel for the manufacturing sector are providing a national service. The tax code should be used constructively to encourage such behavior.
- *Recapitalize manufacturing and the public infrastructure.* To achieve the greater productivity and efficiencies needed in advanced manufacturing, companies must stay current with state-of-the-art technology to achieve greater productivity and efficiency. Government should enact tax credits to encourage manufacturers to re-capitalize their equipment. Still, more is needed than just the renewal of private facilities. The viability of these private efforts is dependent on public infrastructure investments as well. The replacement of roads, airports, canals, and water facilities will boost efficiency of manufacturing and the economy through a multiplier effect. Government spending on infrastructure should be increased.
- *Relax export controls on American manufactured products.* Too much Cold War mentality is still evident in the US government's approach in considering the approval of technology transfers to foreign commercial concerns. For instance, there is a demand for high-speed multi-axis machine tools in countries for which export is currently restricted. Often, our foreign competitors provide machine tools to these restricted countries. This reduces the competitiveness of American machine tool companies. From a security point of view, there is an advantage for American companies to service their exported machines or at least be able to monitor their use. The rule should be not to export any technology directly related to weapons of mass destruction. However, to rule out the export of sophisticated machine tools just because they have the potential of machining

weapons parts is too conservative an approach. Export controls should be greatly curtailed.

- *Reexamine business legislation with international implications.* Commercial legislation must be reassessed for the new global trading environment to ensure American firms are not placed at a competitive disadvantage. In response to a world of international competition and global transnational businesses, a country with overly restrictive commercial practices is likely to discourage new business innovations. Antitrust legislation appropriate for an insular US economy at the beginning of the 20th century may no longer be applicable to the unregulated global capitalism that the transportation and electronic data revolutions have brought into being. Congress should set up a special commission to consolidate and review business legislation.
- *Encourage, through incentives, the merging of commercial and defense firms.* Major defense contractors have consolidated with government encouragement into corporations with little or no commercial sector sales. It is less likely that defense-dominated corporations can take advantage of advanced manufacturing systems and processes as do commercially dominant companies subjected to global competition. The long-term viability of American manufacturing will not come from a defense-centered industry, but from one that has substantial commercial roots to provide a base for investment and an outlet for new technology markets. Defense firms should be encouraged to merge with commercial entities, not with each other. The goal should be for government to buy from commercially dominant firms using commercial practices to ensure a true dual-use industrial base. Tax credits should be extended to do this, and payments should be stopped for defense only mergers.

CONCLUSION

Only a decade ago American manufacturing was being chided for failing to anticipate and counter the successful growth of the Japanese economy. Since then, many US industries have reinvented themselves by adopting advanced manufacturing techniques and boosting overall productivity. Consequently, American manufacturing today is healthy and robust. Still, our manufacturers are only as good as their next evolution of innovations and improvements.

The need for change is clear and ever present. US industry cannot afford to be complacent just because our economy is booming now. Two

representative manufacturing companies learned an important lesson in the 1980s—the *danger of waiting too long to change*. Despite its huge investment in technology and robotics, one company didn't succeed in the marketplace until it realized it had to master the process changes. Today this company is primed for sustained success because it has embraced these process changes. It is designing for manufacture, has established single managers responsible for new products, and it is looking for ways to foster a productive relationship with its workers. The other company was in danger of going out of business, having relied too long on old methods of manufacturing and sales, along with an inventory of older products. Teetering on the brink of disaster, this firm recreated itself, built new product development teams, empowered workers at every level, and created new relationships with its suppliers and customers.

Can a segregated defense industrial base weather these same cyclones of change and remain world class? Not if cost, efficiency, and agility matter. To remain affordable and responsive, defense production must be coupled with the commercial sector. Short of a national policy that would support a standby defense industrial capability, the growth of advanced manufacturing is the most viable method of ensuring the continued competitive advantage of an integrated industrial sector—one capable of continually meeting our national economic and security needs.

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AGRIBUSINESS

ABSTRACT

This report addresses US agribusiness' strategic role as an instrument of national power and the way agribusiness supports national security and other national priorities. It begins with an analysis of the key elements of the US agribusiness industry. The report then defines the industry and its current condition through an analysis of the challenges, the long-term outlook, and the role of government. Next, the report presents conclusions related to five principal areas: optimizing food safety, enhancing food security, feeding a growing world population, maximizing international agricultural trade, and protecting the environment. Finally, it concludes with recommendations for enhancing the industry's current domestic and international agricultural strengths. This report reflects issues and concerns examined throughout the semester—in classroom studies, individual research, interviews with government officials/industry representatives, domestic field visits, and international visits to Brazil, Argentina, and Chile.

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PLACES VISITED

Domestic

Anderson Ranch, Winters, CA
Calgene Research Institute, Davis, CA
California Cattlemen's Association, Sacramento, CA
California Dept. of Food and Agriculture, Sacramento, CA
Davis Farmers Market, Davis CA
DelMonte Tomato Plant, Sacramento, CA
Domaine Chandon Winery, Yountville, CA
Farmer's Rice Cooperative, West Sacramento CA
Fisco Farm & Home, Woodland, CA
New Holland Hay-Baler Manufacturing Facility, New Holland, PA
Ottenberg Bakery, Washington, DC
Rominger Farms, Winters, CA
Smithfield Farms, Smithfield, VA
University of California at Davis, Davis, CA
US Agricultural Research Service, Beltsville, MD
US Dept. of Agriculture, Washington, DC
US House of Representatives Agricultural Committee, Washington, DC
US Natural Resources Conservation Service, Lockeford, CA
Van Warmerdam Dairy, Lodi, CA
Wampler-Longacre, Inc., Poultry Farm, Forestville, VA
Western United Dairymen, Sacramento, CA
Woodland Tractor & Equipment Co., Inc., Woodland, CA

International

Cresta Roja Poultry Farm, La Aurora, Argentina
Argentine Meat Industry Association, Buenos Aires, Argentina
Army Cavalry Headquarters Ejercito Argentino, Buenos Aires, Argentina
Cazenave & Associates, Buenos Aires, Argentina
Central Fruit/Produce Market, Buenos Aires, Argentina
Ministry of Agriculture, Buenos Aires, Argentina
US Embassy, Agriculture Department, Buenos Aires, Argentina
CACIQUE Coffee Processing Plant, Londrina, Brazil
Fazenda Sete Logoas Agricola, Citrus Growers Co-op, Brazil
IAPAR Agricultural Research Center, Londrina, Brazil
US Consulate, Sao Paulo, Brazil
Usina da Barra, Sugar/Alcohol Processing Facility, Barra Bonita, Brazil
Aconcaqua Agricultural Valley, Chile
Concha y Toro Vineyards, Santiago, Chile
Ministry of Agriculture, Santiago, Chile
Pioneer Seed Company, Santiago, Chile
Port of Valparaiso, Valparaiso, Chile
Sociedad Nacional de Agricultura, Santiago, Chile
US Embassy, Agriculture Department, Santiago, Chile

INTRODUCTION

This study focused on the farmer and various agribusiness practices that assure the industry's ability to provide safe, abundant, and affordable food. The study group analyzed those agricultural trends that are bringing profound changes in how food is produced, processed, distributed, and marketed in the US and abroad. Agribusiness is vital to the economic prosperity of the US and directly impacts national security and the economic and political elements of our national power. The industry's ability to produce safe, affordable food to feed the people of this country and to provide crops and other agricultural products for export is important. This ability, in turn, provides our national leaders with opportunities to create, to foster, and to improve international relationships throughout the world. Because every nation must feed its people, agribusiness is universally accepted as an indispensable factor in contributing to domestic stability, international standing, and national power. The farmers in California, Chile, Brazil and Argentina emphasized these viewpoints. They further emphasized the importance of globalization and free market agriculture as irrefutable realities.

THE AGRIBUSINESS INDUSTRY DEFINED

The agribusiness industry is a highly diverse and interdependent sector of the US economy. It includes agricultural producers, businesses that provide supplies and services to producers, and businesses that add value to agricultural products. Agribusiness begins with the American farmer and the suppliers of necessary inputs for farm production. It extends to support elements of the industry such as food processing, wholesale and retail sales, and food brokerage services. Agribusiness also includes the ever-growing food service industry—restaurants. Other industries supporting agribusiness include export and import traders, transportation, and financial institutions.

The US agribusiness industry includes many components.

Farm Input Suppliers. Products provided by input suppliers include farm equipment, seed, feed, chemical fertilizers, herbicides, and pesticides. Inputs extend beyond farm-unique products to oil and fuel, and even to natural gas that is used to produce nitrogen fertilizer. Additionally, various public organizations and private firms provide necessary support services to the agricultural community, e.g., financial

assistance, transportation and storage services, government and private research, and farm extension programs.

Farms and Farmers. Farmers are the backbone of agriculture within the US. There were 2.1 million American farms in 1996 covering 968 million acres. Annual farm employment in 1995 was 2.8 million workers. One US farmer grows enough to feed and clothe 130 people, of whom 36 live outside the US (Walker).

Food Brokers, Wholesalers, and Retailers. Food brokers and wholesalers provide farmers with effective and efficient means for selling, transporting, storing, and distributing their products. Food retailers provide the final marketing and distribution links to consumers, offering them a variety of processed and unprocessed foods for purchase.

Food Processors. The growing food processing industry includes freezing, canning, cooking, baking, packaging, and other preparation activities that add value to raw food commodities.

Food Service Outlets. Food-service outlets are primarily restaurants providing consumers with meals that are ready for on-site consumption or for take-home. This segment of the food industry continues to grow as ever more working Americans spend less time in the kitchen. Fast food restaurants have saturated most markets and continue to dominate this sector of the industry. Food service also includes institutional feeding at locations such as prisons, schools and military installations.

The Agricultural Commodities Market. The commodities exchanges in New York and Chicago are the primary means of risk management in the agribusiness industry. Exchanges provide a venue for buyers and sellers to meet and exchange commodities, to set prices, and to seek stability. Agricultural products make up about 25% of contracts available for trade (Chicago Board of Trade).

Exporters and Importers. As US agriculture relies less on subsidies and moves closer to global free markets, exporters and importers play an increasingly important role. American agriculture relies twice as much on international markets as does the US economy as a whole. According to Secretary of Agriculture Dan Glickman, "In the long-term, trade/global markets, not commodity programs, will define agriculture's future."

CURRENT CONDITION

The US has been, and continues to be, a world leader in food production. Possessing the requisite natural resources, innovative technology, and favorable climate, the US has maintained the ability to

feed its citizens at a very reasonable price while retaining the flexibility to use agriculture as a tool of national power.

Despite the considerable uncertainty raised by the recent economic turmoil in Asia, the US economy is poised to support strong agricultural demand throughout 1998. It appears world economic growth will slow from 3.1% in 1997 to 2.5% in 1998.

Agricultural Production and Sales—Healthy

Current macro statistics project increased demand for US meat, poultry, dairy and horticultural products, and processed foods. This demand also means good news to farmers' cash flow. With energy prices, interest rates, and feed costs down, farm production expenses are forecasted to decline moderately in 1998. This has occurred only twice in the 1990s.

As 1998 dawned, the US agricultural economy continued a slight decline from the record high-income level of 1996. Overall economic performance within the industry is expected to be slightly below the 1990-97 average. The areas of concern continue to be producers in regions affected by bad weather and some wheat, cattle, hog and dairy producers that have had to reduce cash balances or incur debt to withstand short-term financial pressures. Farm cash receipts set a record of \$202 billion in 1996 and again in 1997 (crop receipts were above average and livestock receipts at about average). This year, market receipts are likely to decline to \$198 billion, as lower grain receipts reduce the total return on crops. Livestock receipts will decline somewhat as lower returns on hogs more than offset a small increase in cattle returns; dairy remains about unchanged. Overall production expenses will decline a little, held in check by lower interest rates and lower feed costs. Net cash farm income in 1998 is forecasted to decline to about \$52 billion.

US Agribusiness Exports—Slight Improvement

Lackluster growth in US exports due to large world crops and the Asian currency crisis has contributed to the drop-off in US grain and cotton prices. In 1998, wheat and corn exports are expected to be well below the past 7 years' average; cotton exports are expected to be near this average. US soybean exports, however, are expected to set record highs as world demand for oilseeds continues to expand.

Despite the decline in corn exports, total corn use in 1998 is forecasted to be the second largest on record, as domestic use is expected to expand by nearly 9%. However, declining foreign production and improved economic conditions in Asia should enhance export prospects for corn in 1999.

Farm Business Debt—Reduced

The farm sector balance sheet showed further improvement in 1997 as asset values rose more than debt increased. Farm real estate values have risen every year since the mid 1980s, including a 6% increase in 1997. A 5% gain is expected in 1998. Farmers will take on more debt, reaching the highest debt level since 1985, but the overall debt-to-asset ratio is expected to decline from 15% at the end of 1997 to slightly under 15% at the end of 1998 as farm real estate value rises. This will allow farmers more flexibility for capital investments and will allow them to assume more risk in the next crop season.

Weather Impact—Uncertain

The primary uncertainty for the 1998-1999 crop outlook is the weather. It is uncertain when El Nino will cease and what the following weather pattern will mean for crop plantings and development. All major crop growing areas except the Upper Midwest and Northern Plains have had more than ample soil moisture. Southeastern and Southwestern farmers are concerned that soil will be dry enough at normal planting dates. The more that excess moisture delays planting in the South, the more likely producers will shift from corn to cotton and ultimately to soybeans. Excessive moisture could pose a similar problem for Eastern Corn Belt producers. Delays in planting could leave producers with the choice of planting earlier maturing varieties, with the prospect of lower yields, or switching to soybeans. The switching of acreage to soybeans, combined with the prospect of a record South American soybean crop, could reduce soybean prices and may cause a resultant rise in corn prices. A wet spring followed by a dry summer would support price prospects for both crops; there are not ample stocks available to prevent major price run-ups if a severe drought occurs. If, however, current good conditions for winter wheat continue and other crop yields are above normal, the current, somewhat bearish, price prospects could become much worse.

Demand for Processed Foods—Increasing

Overall US trade in processed foods in 1996 rose 6.5% from 1995—somewhat smaller than the 10.7% and 8.6% jumps of the previous two years, but strong nonetheless. Imports led the growth in 1996. Processed food imports averaged a 4% annual growth rate over the previous five years, but grew an astounding 11.2% (to \$27.8 billion) in 1996. Exports, by comparison, grew only 2.5%, to \$30.1 billion, well below their average growth rate for the past five years. The processed foods trade surplus amounted to \$2.4 billion, down from the record \$4.4 billion in 1995, but still the third largest on record (Ruppel and Handy, p.1).

CHALLENGES

Food Safety

The American consumer relies upon—and takes for granted—a safe food supply. However, recent episodes of contamination and disease have raised the level of consumer concern and awareness around the world. Whether “mad cow” disease in English beef cattle or *E. coli* contamination in American hamburger, these events sustain pressure on the agriculture industry and responsible government agencies to eliminate the possibility of future occurrences. The challenge is twofold: to manage production processes efficiently and effectively, and to minimize contamination possibilities and to earn/maintain a high state of consumer confidence in the safety of its food supply.

US Initiatives. In January 1997, President Clinton announced the Interagency Food Safety Initiative encouraging collaboration among industry, government, and consumers to ensure the safety of food from farm-to-table. It includes several components for improving the federal food inspection system: expand consumer education, develop voluntary measures to reduce the risk of pathogenic contamination of animals on the farm, and facilitate a nationwide transformation of state-mandated production quality programs to a national Hazard Analysis and Critical Control Point (HACCP) system.

Foodborne Illnesses. The problem of foodborne illness is significant. It permeates the food chain and requires national effort and attention. The problem is not isolated within our nation’s borders. Human costs of foodborne illness are enormous. Annually, nearly 33 million Americans become ill and approximately 9,000 persons die each year. The US is taking nationwide measures to reduce pathogens in the

food supply system. If pathogens are reduced by an expected 90%, the anticipated reductions in medical costs and productivity losses may result in savings of approximately \$170 billion annually (Billy, 1997).

Ensuring the Safety of Imported Products. The US has a sound system for ensuring the safety of imported meat and poultry. The US Department of Agriculture (USDA) reviews and approves the meat and poultry systems in countries that export to the US to ensure that inspection procedures, quality standards, and other requirements are "at least equal to" those of the US. Meat is also reinspected at ports of entry before being allowed into the US. USDA will halt the importation of meat and poultry from countries where food safety systems are not on par with the US system, and where problems are detected at ports of entry. A similar program exists through the USDA's Animal and Plant Health Inspection Service that helps ensure the safety of imported fruits and vegetables.

International Agricultural Trade

The borders between countries, companies, and currencies are disappearing. The globalization of agribusiness is a recent phenomenon, spurred on by rapid improvement in communication, transportation, and financial technologies. Today, the US is an agricultural superpower; agriculture is the bedrock of our national strength. America's place on the world stage is dictated by the trade of its vast surpluses of various agricultural products. In today's world, one farmer produces enough agricultural products to support 130 people, with approximately 28% going overseas. This surplus, in addition to the ever-increasing efficiency of US farms, provides great opportunities for foreign trade in agricultural products and a positive influence on our balance of trade.

Government Policy. The Federal Agriculture Improvement and Reform Act (FAIR) of 1996, from now on called the 1996 Farm Bill, has accomplished its goal of liberalizing trade by reorienting segments of American agriculture toward a free market with less government involvement and control. The 1996 Farm Bill is essentially a "freedom to farm" act that gives farmers the latitude to plant what they think the domestic and global markets will bear. It fundamentally redesigns income support programs and ends income supplements.

Trade Policies/Agreements. Trade policies and trade agreements play a significant role in the health of the agricultural industry and directly influence the importance of agriculture as an element of national

power. Trade liberalization, for example, is increasing demand for US products and influencing industry and government policymakers.

US agricultural trade is a significant contributor to the US balance of trade. Agriculture had a positive net surplus of \$27.4 billion in 1996 and \$21 billion in 1997 (Economic Research Service, 1997a, p. 3). Liberalized trade policies under the Uruguay Round of the General Agreement on Trade and Tariffs (GATT), the North American Free Trade Agreement (NAFTA), and the 1996 Farm Bill play a key role in shaping this demand. Since NAFTA was implemented, US agricultural exports to participants increased from \$8.87 billion in 1993 to a record \$11.59 billion in 1996, resulting in a trade surplus of more than \$1 billion.

New challenges threaten access to foreign markets. They include qualitative trade barriers such as the European Union's special labeling requirements and outright ban on genetically modified organisms for improved insect/weed management and reduced pesticide use. The lack of Presidential "fast track" authority to negotiate trade agreements expired in 1996 and remains an issue of contention between Congress and the White House. This limits US participation in certain regional and multilateral trade agreements that might reduce current import taxes levied on US agriculture products. The success of the MERCOSUR (Southern Common Market) multilateral trade agreement in opening markets and increasing trade was evident throughout the study group's trip to South America.

The Environmental Trade Connection. National and international attention is focused on the linkages between environment, trade, and agriculture. The use of environmentally sensitive farming practices is becoming more widespread globally and affects the competitiveness of agricultural products in the international marketplace. US farmers must produce agricultural products at reasonable prices—using production systems that preserve and even enhance the environment—while remaining price competitive on an international scale. While the World Trade Organization does not sanction using trade policies to enforce environmental issues, increasing global concern is being reflected in more recent multilateral trade agreements, policies and programs.

The Environment

The competition for land, especially productive agricultural land, continues to intensify. Land is increasingly at risk from urban sprawl and rural subdivision. We are converting more than a million acres a

year from agriculture to other nonagricultural uses. States recognize the significance of converting agricultural lands to other uses and have initiated additional programs aimed at saving farmland. Farmland protection tools include the Farmland Protection Program, Agricultural Protection Zoning, and local Right-to-Farm ordinances.

Water Resources. Even though industrial contaminants have been reduced, streams, lakes, and coastal/inland waterways are still polluted. Sources of pollution such as the runoff of agricultural fertilizers and animal waste contributed to impairment in 60% of the 36% of rivers found to have water impairments. Strict water pollution controls on American farmers have sometimes been viewed as inappropriate and unnecessary. To this point, most controls have been voluntary.

However, public awareness is increasing and public frustration with polluted runoff is intensifying not only in the US, but also in Argentina, Brazil, and Chile. Congress is focusing on pollution from farm runoff and is considering legislation to control waste originating from large-scale livestock and poultry operations. The combination of state and federal regulations for waste management; technical, educational, and financial assistance to farmers and ranchers; and riparian buffer zones along waterways should prove highly effective in reducing nutrient pollution to acceptable levels thus restoring the health of our aqua-ecosystems.

Water availability is a key concern, too. The competition for water among agriculture, industry, wildlife/wetland conservation, and household use continues to intensify in many parts of the US and the world. The competing demands on a limited amount of water are leading to heated legal battles over water rights. This debate is particularly sharp in California with urban users lining up against conservationists and farmers.

As populations continue to explode worldwide, the demands for water will grow accordingly. The free flow of water across borders will become an increasingly contentious issue as nations struggle to maintain useable water supplies for household, industrial and agricultural use.

Soil Resources. The number one productivity problem facing farmers is the loss of arable land through soil erosion. The loss of soil degrades arable land and eventually renders it unproductive. Worldwide, between 22 to 25 million acres of arable land are destroyed and abandoned annually because of unsustainable farming practices. (Conservation Technology Information Center, p.1).

While the highest erosion rates are in Asia, Africa and South America, the US also experiences high levels of erosion. Many

techniques and technologies have been developed that have proven reliable in soil conservation including, ridge-planting, no-till cultivation, crop rotations, strip cropping, grass strips, mulches, living mulches, agroforestry, terracing, contour planting, cover crops, and windbreaks. Each method can be used separately or in combination with other methods depending on soil type, specific crop or pasture, slope and climate.

In the US, over 300 million acres are farmed using some type of reduced tillage practice (Conservation Technology Information Center, p.1). In Brazil, there are 5.2 million acres under reduced tillage practices. Only about 5% of Argentina's croplands are farmed this way. The use of reduced tillage in Chile is still smaller.

Harnessing Technology

US agriculture is benefiting from a new wave of advanced technology designed to improve efficiency and provide farmers with the tools they need to remain competitive in the global marketplace. They include improvements in information, machinery, plant, crop and animal technologies that result in higher productivity, lower costs, and a cleaner environment.

Crops. Precision farming is a strategy that employs detailed and site-specific information to manage production inputs. By correlating knowledge of unique soil and crop characteristics in each part of the field, production inputs can be optimized to each small portion of the field. As a result, inputs are minimized and outputs maximized. Global Positioning Systems (GPS) installed on tractors make these methods highly accurate. In the future, radar systems designed for troop detection could measure cotton growth. Nonpiloted aircraft designed to chart weather patterns may detect soil moisture (McKinioll).

Scientists are accelerating agricultural improvements through genetic modifications called transgenics. Through the manipulation of eggs and gene characteristic transfer, traits have been introduced into crops to improve marketability and tolerances to herbicide, insects, and viruses. The FlavrSavr® tomato and RoundUp Ready® crops are two examples. It is estimated that sales of transgenic crops will rise from \$420 million in 1998 to \$2,300 million by 2008 (Rotman).

Sustainable Agriculture. Environmentally friendly farming practices are becoming more widespread. Farmers can apply "green" practices at various stages of production and farmers often apply more than one practice during a production phase. Using various approaches, US

farmers are making great strides in the use of sustainable agricultural practices. They are extending the creative application of Internet information, remote sensing technology, and precision or site specific agriculture. These increase farmers' decision-making capacities, significantly reduce production costs, and minimize the environmental impact of overuse of pesticides. "Green" practices also improve crop quality and reduce the use of fertilizers.

Animals. New areas are being studied using animal transgenics. Scientists have identified, mapped and manipulated genes that control characteristics such as growth rates, fat-to-lean ratios, milk yields, heartiness, and meat tenderness. The results are improved products for human consumption, medical purposes, and for animal feed.

The expected results from transgenic animals are astounding. Cows and goats could be used as "bioreactors" to produce pharmaceuticals in their milk and urine. Chickens will be produced in less than a third of the time it took in 1950. The number of pigs produced per sow could be doubled. Cattle could be genetically matched to the climate. Catfish and trout could have genes incorporated to make them reach maturity—and the market faster (Miller-Hays).

Feeding the World's Growing Population

The key challenge facing the agribusiness industry of the future will be its ability to feed an ever-growing world population. Each year an additional 80 million people must be fed. As population levels increase, the demand for agricultural products and competition for the use of available farmland will increase. According to estimates, the world demand for food will double by the year 2030 with little or no new farmland available to produce crops. There is a fixed amount of arable land in the world. While deforestation continues to increase farm acreage and farm production in places such as the Amazon basin in Brazil, the Earth's inhabitants will have exploited all available land early in the 21st century.

A secondary requirement for increased productivity deals with changing demographics and the rising affluence of working class people. As more people live in industrial centers with higher paying jobs, more money becomes available to support a larger, more varied diet. This increases the overall demand for the amount and types of foods required. The American farmer has consistently increased productivity levels over the last 50 years to meet the demands of the market place—generated

primarily by increasing populations. Whether or not American farmers can continue this trend is a key challenge for the 21st century.

Methods for Increased Productivity. Farmers around the world use a variety of productivity-enhancing tools. They can be employed singly or in various combinations, as described. First, mechanization usually improves efficiency and may ultimately reduce costs. However, there are many parts of the world that cannot afford the significant investment in mechanization. Second, a low cost method of protecting soil is by terracing of fields and by low/no till planting. Third, advances in precision farming will increase productivity. This includes the precise application of herbicides, pesticides, and fertilizers. Fourth, genetically engineered plants yield larger crops and are more robust than natural plants. Finally, irrigation contributes to larger yields, overcomes shortages of rainfall, and allows crop production on lands that would normally be barren. The study group found some or all of these tools being used across the US and throughout South America. Farmers in Brazil, Argentina, and Chile are adopting all these practices as fast as they can learn them and/or afford them.

OUTLOOK

The US is and will remain an "Agricultural Superpower" over the short-term (1-5 years) and into the foreseeable future. America will maintain the ability to feed its citizens at a very reasonable price while retaining the flexibility to use food and trade in agricultural products as a tool of national power. Agricultural industrial capability can support military operations up to and including two nearly simultaneous major theater wars without major disruption to the civilian market. While potential shortfalls have been identified in processing and packaging of individual and group combat rations, actions are in place to allow for surge production.

Productivity

Productivity must continue to improve. As previously identified, increasing world population, conversion of agricultural land to other uses, and demographic shifts of labor away from farm occupations drive this requirement. While the rate of productivity gains of American producers will slow in the long-term, it will continue upward. In many overseas areas (some of which already have productivity advantages, e.g., sugar production in Brazil), the rate of productivity gain will, in the

short-term and through at least the middle of the long-term period, outstrip US gains. This will be the result of continued widespread adoption of information, mechanization, agri-chemical, and other technology already in place in the US.

These productivity gains will come principally from improved plants and animals, improved fertilizer and pest control, increased mechanization in both production and processing, and free market pressures. Each of these areas is discussed below.

Improvement in both plants and animals are being achieved through both traditional breeding techniques and genetic engineering. In the past, these improvements have centered on pest and disease resistance, herbicide resistance, improved product quality, and increased yield. Additionally in animals, there has also been some reduction in fat content while maintaining quality and palatability.

In the near-term, improvements in these areas will continue, and we will begin to see significant modifications of both plants and animals for human nutritional benefit. The acceptance of genetically engineered products at farmer, consumer, and governmental levels will grow. In the long-term, genetically engineered products will become the norm, yielding both increased production with reduced inputs, and significant health benefits to the consumer. The use of plants and the more widespread use of animals to produce pharmaceuticals will become practical, too.

Improvements in fertilizers and pest control techniques will continue in both the short- and long-term. Integrated pest control using plant and animals as well as insecticides will continue to grow in popularity. Precision farming techniques integrating GPS, yield monitoring, soil analysis, and improved delivery technologies will become more widely accepted as prices come down. The use of these techniques and technologies will become widespread worldwide in the long-term.

Mechanization, both to reduce the dependence on manual labor and to increase quality, will continue in the farming and processing sectors. In the long- and short-term, equipment manufacturers, aided by agricultural researchers worldwide, will continue to develop and market appropriate technology. In some cases, this will be larger and more powerful tractors and combines while in others it may be horse-drawn planters. The key is having the right equipment for the size and conditions of production or processing.

Finally, productivity of US agribusiness will be enhanced by a move to reduced or eliminated government interference in the market. The 1996 Farm Bill begins to unfetter the farmer and the market; it will allow

farmers to grow the most profitable crops guided by market forces. In those countries with minimum government interference such as Chile and Argentina, this has resulted in improved productivity.

Consumer Demand Patterns

Demand will continue to shift from fresh to more processed products domestically and around the world. With increased income and more two-earner households, demand for enhanced quality and ease of preparation will grow. Additionally, some US consumers are willing to pay more for organic foods.

These changes in consumer demand will allow traditional producers of raw agricultural products to increase their profit by performing value-added processing prior to export, and by appealing to such niche markets as organic vegetables.

Food Safety

The safety of our food supply will continue to be an important governmental and consumer concern. Initiatives such as HACCP and ISO 9000 series quality certification program will spread to our agricultural trading partners. Education of consumers and food service workers will also become more important in preventing foodborne illnesses.

While there are no technological barriers to the use of irradiation, in the short-term consumer reluctance will effectively prevent its widespread use. Improvements to the inspection process, particularly use of microbiological testing, will remain the main line of defense. In the long-term, irradiation and ozone technologies will play a significant role in ensuring food safety.

Environment

Increased awareness of the impact of agricultural practices on the quality of the environment, coupled with significant reductions in industrial and municipal contamination streams, will result in increased [enforcement] pressure on farmers, dairymen, and livestock producers/processors to meet clean water standards. At national and state levels, environmental laws, as they apply to agriculture, will be tightened. Current incentives such as payment for land set aside for riparian strips will be continued and expanded in the short-term. Many

of the advances in agricultural productivity will also assist in meeting water pollution abatement requirements.

While this push for enforcement is most evident in the US, similar requirements are on the horizon in the South American countries that the study group visited. As these and other countries bring industrial pollution under control, environmental focus will shift toward agricultural pollution.

Acceptance of a wide range of techniques and practices to control the loss of topsoil will grow over the short-term. Of particular note are use of low/no till techniques, terracing, green manure cover crops, and drip irrigation. The keys to the increased use of these and other soil conservation practices is the education of farmers, cost effective availability of pest/weed control chemicals, and adaptable planting and tilling equipment both domestically and worldwide.

Global Markets: Trade Surpluses and Exports

Overall, the market for US farm and food products is likely to grow in the years ahead. Favorable global economic growth and free trade agreements associated with GATT, NAFTA and unilateral US policy reforms, support strong growth in world agricultural trade and US exports. Export markets provide a vital outlet for US farmers to sell their products and are necessary for the profitable use of America's productive capacity. In 1996, production from more than a third of US cropland went to satisfy export demands. The US exported an estimated 44% of the wheat crop, 45% of the rice crop, 37% of the soybean crop, 19% of the corn crop, and 37% of the cotton crop in the 1996 market year. Exports in 1996 reached \$60.4 billion, doubling the level of 1986.

The top ten markets for US agricultural products include Japan, European Union, Canada, Mexico, South Korea, Taiwan, China, Hong Kong, Russia, and Egypt. The total value of US agriculture exports are projected to rise from a record of \$60.4 billion in 1996 to \$62.7 billion in fiscal year 2000 and approach \$80 billion in 2005, an increase of 5% annually. The US continues to lead the world as the top exporter of agricultural products.

We will continue being the world's leader vis-à-vis encouraging a barrier-free trade environment. The US will participate in creating a Free Trade Area of the Americas (FTAA). While the availability of "fast track" authority will influence our nation's ability to expand the number and breadth of trade agreements, increased agriculture trade will continue to be a key component of US trade strategy. Free trade will

affect the US ability to produce adequate food to meet domestic and foreign needs, improve the environment, and provide sufficient earnings to agribusiness participants.

World Food Security

There is international agreement that we need to act now to solve future world food problems. The World Food Summit, held in November 1996 in Rome, Italy adopted a 186-country Rome Declaration and World Food Summit Plan of Action. This plan sets the goal of reducing the number of undernourished people by half no later than the year 2015 and identifying actions that nations should take to achieve that goal. The US endorsed the plan and subsequently adopted the goal as a domestic target. The US developed the US Action Plan on Food Security to strengthen what the public and private sectors must do to reduce hunger and malnutrition at home and abroad.

In the long run, food security can be achieved if we can accomplish four tasks: develop sustainable production systems capable of nearly doubling output; put in place domestic and international policies and institutions that do not favor industrial development over agricultural development—providing appropriate incentives to farmers around the world; continue to invest in public agricultural research through such organizations as the Consultative Group on International Agricultural Research; and persist in removing distortions to free agricultural trade in all countries. The US, more than any other nation, has the capability and the responsibility to provide the necessary leadership to ensure that the world's inhabitants are fed.

GOVERNMENT GOALS AND ROLE

Background

Historically, the US government played a significant role in the agriculture sector. It paid people to develop farmlands, provided for agricultural institutions of higher learning, helped fund agricultural research, and protected the agricultural community from foreign competition (Loker, p. 1). The government also provided relief to the nation's farmers stricken by drought, dust bowls, debt, and decreased crop prices. More recently, the government developed programs that included artificially high crop support prices, reduced the amount of land in production, and bought crop surpluses. During the late 1980s, federal

agricultural expenditures peaked as Congress modified agricultural legislation to stimulate foreign markets while maintaining farm income support (Robinson, pp. 1-2).

Changes

Mounting pressure to reduce the federal deficit caused significant changes in the government's role in agriculture. During the 1990s and into the 21st century, the government will play an ever-decreasing role in the agriculture sector. For example, the 1990 Farm Bill reduced federal spending on farm programs and developed free-market trade philosophies. The most recent legislation, the 1996 Farm Bill, establishes landmark US farm policy. It continues phasing out subsidy programs for price sensitive deficiency payments and provides for predetermined direct payments to farmers until 2002. It eliminates most acreage use restrictions and dairy price supports beginning in 2000. It also suspends the Farmer Owned Reserve program and reduces funds for commercial agricultural export programs. Additionally, it extends the conservation/wetland reserve program and Food Stamp programs, while authorizing new rural development programs. Finally, it modifies the farm credit and agricultural commodity programs (Economic Research Service, 1996).

Farmer

Farmers must become more self-reliant as support and subsidy programs are reduced and/or phased out. To remain profitable, farmers must do the following: learn how to determine what to grow and how much to grow using marketing tools and knowledge; determine what to insure (crop and percentage) and for what amount; develop their own marketing strategy to weather the changes ahead; reduce their dependence on government subsidies; and keep abreast of changing global market opportunities.

However, the 1996 Farm Bill allows the farmer to enjoy cheaper credit. Farmers may obtain farm credit more easily, thereby making farming and ranching operations a reality for young and novice farmers. (US House of Representatives Committee on Agriculture, pp.26-27). (Johnson, p.2) Farmers can be more flexible in their response to market signals rather than being "locked" into historical planting patterns. They will have less paperwork and will be able to determine crop rotation practices to suit their own best interest. Additionally, they will save

money given self-determined crop rotation—requiring fewer applications of herbicides and insecticides. Farmers may also put some land, previously classified as environmentally sensitive, back into production to meet market demands (US House of Representatives Committee on Agriculture, p.22). They will remain protected against the effects of suspended agricultural exports because the Secretary of Agriculture must provide compensation if the US prohibits exports (US House of Representatives Committee on Agriculture, p.8). Finally, it may result in fewer and fewer small farms and more consolidations and vertical alliances because some 34,000 farms depend upon government payments (for over 20% of their gross income) to survive. (Economic Research Service, 1997b, pp.20-21).

Research and Development

No prior farm legislation emphasized research to the extent stressed in the 1996 Farm Bill. It favorably impacts the scientist in five major ways. First, scientists may acquire up to \$200 million that Congress has deposited into a fund (to be used over 3 years) for research and rural development activities. Second, the 1996 Farm Bill created a competitive grant program for projects that increase competitiveness, efficiency, profitability, and reduce health risks (US House of Representatives Committee on Agriculture, p.30). Third, it permitted the creation of three new research and promotion programs designed to assist various industries via advertising, promotion, and product/market research as a means to enhance agricultural competitiveness (US House of Representatives Committee on Agriculture, p.25). Fourth, it gave USDA authority to implement nationwide research and promotion programs (Economic Research Service, 1996, p.vii). Finally, and probably most significantly, the 1996 Farm Bill established a task force to develop a 10-year strategic plan for agricultural facilities. The task force will address development, modernization, consolidation, and closure of federal agriculture research facilities risks (US House of Representatives Committee on Agriculture, p.30).

Environment

The 1996 Farm Bill is the "greenest" farm bill ever. Farmers determine what to plant and where. They have the freedom to rotate crops, building soil fertility and health naturally (e.g., fewer applications of herbicides and insecticides). The 1996 Farm Bill re-authorizes the

Conservation Reserve Program (CRP) targeted at 36.4 million acres of environmentally sensitive land. The CRP keeps some 700+ million tons of topsoil from erosion each year and provides a wildlife habitat equivalent in size to the state of Iowa. (US House of Representatives Committee on Agriculture, p.7).

The 1996 Farm Bill protects other water and soil resources through the Environmental Quality Incentives Program (EQIP)—providing cost-share and technical assistance to farmers for water quality and soil protection. This program guarantees over \$1.2 billion to protect these resources (US House of Representatives Committee on Agriculture, p. 21).

Finally, the 1996 Farm Bill sets aside fragile lands that provide crucial wildlife habitat in their natural state and safeguards wetlands in farming areas (National Wildlife Federation, p.1).

Future Role of Government

The success or failure of the 1996 Farm Bill depends upon how well American farmers adapt to a free market environment. Future agricultural policy will be determined, in the near-term, by the Commission on 21st Century Production Agriculture, which was created by the 1996 Farm Bill (US House of Representatives Committee on Agriculture, p. 17).

Its primary purpose is twofold. First, the commission will review the status of American farming since passage of the 1996 Farm Bill. It will examine the situation American farmers face at home and abroad and the type of federal involvement required after the 7-year act ends in 2002. The commission's first report is due by June 1, 1998. Second, the commission will examine where American agriculture is headed in the 21st century. It will issue a "look forward" report (by January 1, 2001) outlining farming changes that have been made in the last 5 years. The report will also make specific recommendations regarding government involvement in American farming's future (US House of Representatives Committee on Agriculture, p. 18).

As seen in the South American countries that the study group visited, it seemed minimal federal government intervention and interference worked best for creating a true market environment that precipitated increased productivity and reduced consumer burden.

CONCLUSION

There are no significant changes in the structure, standing, or relative ranking of the agricultural capacities of nations expected in the foreseeable future. The US is self-sufficient in agricultural production. It remains the most powerful agricultural nation in the world, enjoying both competitive and comparative advantage. Continued increases in productivity within the American agricultural industry will further strengthen our standing and contribute to increased levels of export. Farmers will continue to improve efficiencies in farm operations, while at the same time reducing their impact on the environment. Genetically engineered crops and animals will contribute to anticipated efficiency gains. Needless to say, increased agricultural production is required to feed an ever-growing world population.

The expansion of free trade policies throughout the international community—enabled by continued reduction in tariffs and quotas—will open more markets to American products. While a staunch supporter of "free trade," the US continues to maintain a protectionist stance on some commodities such as imported beef and sugar. If America is to remain the leading and most influential agricultural nation, it must continue to eliminate its own trade barriers and selective protectionist actions—through a negotiated process with all its trading partners. The restoration of Presidential "fast track" authority will contribute to national power by facilitating the negotiation of bilateral and multi-lateral trade agreements.

The agribusiness industry is the bedrock of America's national security. It directly contributes to the economic and political power of the US. To maintain our position of agricultural leadership, we must continue to lead the world in research and development of new technology; drop our trade barriers, encouraging other nations to do so as well; and minimize government intervention in the agricultural marketplace, allowing informed participants to make decisions in their own best interest. In the long run, these actions will keep America at the forefront of global agriculture; a position earned through the hard work and dedicated efforts of everyone in the agribusiness industry.

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AIRCRAFT

ABSTRACT

The domestic aircraft industry is one of the US strongest strategic assets that underpins our national defense and economic power. The strength of US national security strategy rests on America's unmatched heavy lift and combat airpower. Aircraft production is a crucial component of the economy, generating 1.2% of GDP and 6.5% of US export sales. The global industry is coping with significant restructuring, shrinking supplier base, increased international competition, and divergent market trends for commercial and military aircraft, and changing government roles. The industry restructuring is occurring as companies merge and shed noncore business activities to reduce costs and become more competitive in the global market. Some countries are undergoing increased privatization of their industries, while others are dealing with an expanded government role in protecting key industrial capabilities. This analysis focuses on these challenges and their impact on the fixed wing, rotary wing, and engine sectors of the industry.

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PLACES VISITED

Domestic

Aerospace Industries Association, Washington, DC
Boeing Military Aircraft, St. Louis, MO
Defense Logistics Agency, Defense Supply Center, Richmond, VA
Douglas Aircraft, Long Beach, CA
General Electric Engines, Cincinnati, OH
Lockheed-Martin Skunk Works, Palmdale, CA
Northrop-Grumman Corporation, Palmdale, CA
Pratt & Whitney, East Hartford, CT
Shultz Steel Company, South Gate, CA
Sikorsky Aircraft Corporation, Bridgeport, CT
Smithsonian Museum, Aircraft Refurbishment Facility, Suitland, MD
The Boeing Company, Seattle, WA
The Boeing Company (Helicopter Division), Philadelphia, PA
United Airlines, Chicago, IL
United Technologies, East Hartford, CT

International

Aerospatiale, Toulouse, France
Airbus Industrie, Toulouse, France
Dassault Aviation, Argenteuil, France
SNECMA, Villaroche, France
British Aerospace Defence Ltd., Warton Aerodrome, UK
GKN Westland, Bristol, UK
Ministry of Defence UK, Bristol, UK
Rolls Royce Military Aero Engines, Ltd., Bristol, UK

INTRODUCTION

The US aircraft industry is a strategic industry that serves as a foundation for our nation's security and economic strength. The fixed-wing aircraft, rotary-wing aircraft, and aircraft engine sectors of the aircraft industry provide unique capabilities, however, there are many issues that are common to all sectors of the industry. This study includes an analysis of each sector within the aircraft industry and its cross-cutting issues.

THE AIRCRAFT INDUSTRY DEFINED

Commercial Fixed-Wing Aircraft

The commercial fixed wing aircraft industry includes small general aviation aircraft, medium capacity passenger aircraft, large passenger aircraft, and large cargo aircraft. This report focuses primarily on large jet aircraft that carry 100 passengers or more and cargo versions of those airframes. This sector consists of two major competitors: Boeing in the US and Airbus Industries in Europe. The two companies are expected to deliver close to 800 commercial transport aircraft in 1998.

Current Condition. The commercial aircraft industry currently benefits from the largest commercial aviation boom in history. In 1997, the US aerospace industry increased civil aircraft sales by 15% to \$69 billion, marking the first time since World War II that commercial orders have exceeded military orders. However, the aircraft industry backlog is significant, equating to 2 years of production. To meet production demand, Boeing had to contend with production challenges related to lack of skilled workers, raw material shortages, internal and supplier parts shortages, productivity problems, and management focus on restructuring activities. Airbus has faced many of the same challenges but has still managed to increase production over 60% in 1997 with streamlined production, cost and design innovations, and capacity expansion.

Competition is particularly intense regarding price, operating costs, and production schedule. To manage costs and to meet customer demands, a closer relationship has been developed among customers, manufacturers, and suppliers. Major manufacturers are teaming with suppliers, pushing responsibility for quality and product capability to the vendor base. Additionally, component manufacturers have been asked to assume greater risk in the design and production of new aircraft. Manufacturers have been able to minimize inventories with just-in-time delivery and conservative ordering of parts and supplies.

The prevalent trend in the aircraft industry is restructuring. The consolidation of Boeing, McDonnell Douglas, and Rockwell International forced the integration of three separate corporate cultures and \$20 billion worth of operations. This strategy entailed the divestiture of excess facilities and noncore business activities to contain costs and focus on core competencies. Similar consolidations in Europe, such as the impending conversion of the Airbus consortium into Airbus SCE (Single Corporation Entity), present the potential for eliminating inefficient business practices supported by national subsidies.

Challenges. The principal challenge facing the US commercial aircraft industry is increasing production while containing costs. Production delays by Boeing in 1997 resulted in the company's first net financial loss in 50 years. The second significant challenge facing the industry is meeting setbacks created by the Asian economic crisis. The Asian market constitutes one third of the backlogs and one third of aircraft orders. To a limited extent, the Asian downturn will relieve backlog and associated delays in delivery schedules.

Outlook. Projected production trends over the next 10 years reveal sales of approximately 5,294 commercial jet transports valued at \$358.2 billion. This appears to be sufficient market demand to support two global commercial aircraft producers. The overseas markets are critical to US manufacturers because they will be the major source of future growth. Industry restructure, closer relationships among customer, manufacturer and suppliers, and innovations in technology and manufacturing processes have the potential to increase the competitiveness of US manufacturers.

Military Fixed-Wing

The Military Fixed-Wing sector consists of strategic, tactical, and support aircraft designed and built for military purposes. Unlike commercial aircraft, mission effectiveness drives the design, acquisition and maintenance costs of military systems.

For those countries committed to military aircraft as a strategic industry, acquisition and support costs are less important than the overriding security objectives that underlie force size and modernization decisions. Security requirements often drive countries to design and build aircraft within their domestic industry even if similar capabilities exist in the international market.

Current Condition. The military fixed-wing sector continues to face lean times. Defense spending in the US and Western Europe seems to have stabilized, but planned increases in acquisition funding needed to

recapitalize tactical aviation have not materialized because disproportionately high operations and support costs continue to drain modernization accounts. Reduced defense budgets only support low domestic buys, which pressures producers to look to export sales as a way of increasing quantities and profitability. The result is stiff international competition and a push to reduce life cycle costs of acquisition and support of military aircraft.

The US market is dominated by the Defense Department's plan to modernize its tactical aircraft inventory over the next 10-15 years, replacing the F-14 and F-15 with F/A-18E/F and F-22 and the F/A-18A/B/C/D and F-16 with the Joint Strike Fighter. Trainer and cargo aircraft (Boeing's T-45 and C-17) will continue production at low rates.

The merger of Boeing and McDonnell Douglas leaves Boeing and Lockheed Martin as the prime contractors producing fixed-wing military aircraft within the US. Lockheed Martin's F-22 (with substantial Boeing subcontract content) is conducting initial developmental flight testing for the Air Force. Boeing's F/A-18E/F is completing developmental testing and has entered low rate initial production for the Navy. Both companies have foreign military sales of earlier products (F-15, F-16, and F/A-18C/D) in production at low rates. In addition, both are contenders for the Joint Strike Fighter (JSF) early in its development. The low production rates planned for the F/A-18E/F and F-22 will keep unit prices high.

Overseas manufacturers include the Eurofighter Consortium, Dassault, and Saab. Offerings include the multinational Eurofighter, Dassault's Mirage 2000 and the newly launched Rafale, and Saab's Gripen.

Challenges. There is weak political and popular support for investment in modernizing existing tactical aircraft inventories. With no clear threat, the need to allocate a larger portion of national resources to military systems modernization loses its imperative. Lean manufacturing initiatives and increased emphasis on controlling total ownership costs are required in order to finance modernization within existing budget constraints.

Although international competition for military aircraft is fierce, foreign sales are important to the US for two reasons. First, international sales decrease unit costs and enable the US to maintain a warm (up and running) production line for spares and repairs of domestic systems after domestic production has ended. Second, foreign military sales increase military-to-military diplomatic contacts and interoperability.

Military aircraft available for sale in the international market include Boeing's F/A-18C/D, Lockheed Martin's F-16, Dassault's Mirage 2000 and Rafale and Saab's Gripen. These aircraft incorporate modern weapons systems; selection will generally be based on a combination of technical evaluation, cost, financing, and industrial participation (offsets).

The need to reduce the cost of operating and maintaining aircraft promotes innovative approaches to logistics support. These support approaches offer low cost technology insertion, just-in-time style inventory reductions and rely on premium transportation and original equipment manufacturer depot support in lieu of traditional military organic depots and a just-in-case infrastructure. Successfully adopting these new approaches requires trust and teaming with prime contractors and contractor acceptance of commercial levels of financial risks.

Outlook. The fixed-wing military aircraft sector is poised to begin slow growth at low to moderate production rates. Current acquisition plans, if executed, will create an upswing in the tactical aircraft market over the next 10 years. The European Union's "Future Large Aircraft" requirement for transport modernization is the only nontactical program start envisioned. Development of advanced Uninhabited Air Vehicles (UAVs) continues as the future of the air war is debated. Success in the export market will lead to lower unit costs for domestic purchases and will maintain the support infrastructure for aircraft that will remain in domestic inventories through the first decade of the next century. National security considerations will ensure continued military aircraft production and continued competition for export sales in the global marketplace. The market will reward the manufacturers who can best adopt lean manufacturing practices and leverage flexible sustainment to reduce life cycle costs.

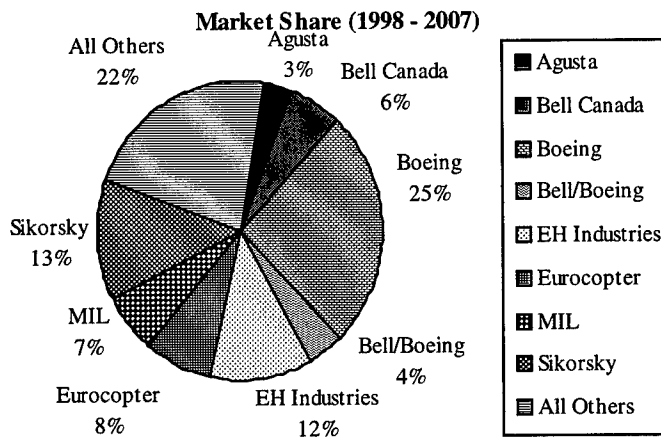
Rotary-Wing Aircraft

The rotary wing sector consists of military and civilian helicopters and tilt rotor aircraft. These categories can be subdivided by gross weight. The major US producers are Bell Helicopter Textron, Inc., Boeing Defense and Space Group and Sikorsky Aircraft, and United Technologies Inc. Foreign producers include Eurocopter (a French and German consortium), Agusta (Italy), GKN Westland (Great Britain), MIL and Kamov (Russia), and Hindustan (India). Japan and South Korea primarily coproduce American helicopters in their countries.

Each producer has pursued niche markets defined by weight and mission to ensure survival and profitability.

Current Condition. The worldwide market for helicopters and tilt rotor aircraft was \$5.27 billion in 1997. The market is predicted to remain stable in terms of numbers produced, however the dollar value of production will increase as customers demand larger, multiengine turbine helicopters with advanced integrated avionics, visionics, and automated flight control systems. The civilian market for helicopter purchases exceeds the military market in number of aircraft produced (714 civilian versus 449 military), but the value of military production and retrofit exceeds the civilian value by a factor of three (\$3.96 billion military versus \$1.31 billion civilian). Growth and profitability in the rotary wing sector is, therefore, highly dependant on the military market.

Figure 1: Rotary-Wing Aircraft Market Share



Source: 1998 American Helicopter Society Annual

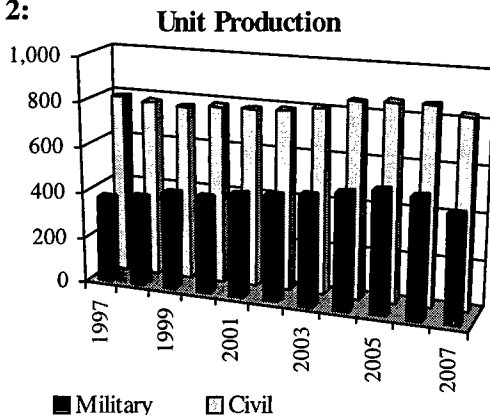
Challenges. Decreasing procurement of helicopters by DoD has forced the US industry to concentrate on military remanufacturing and retrofit programs, maintenance and depot support to the military customer, and commercial sales. In the commercial market, the ultimate challenge is to produce helicopters and tilt rotor aircraft that are cost competitive by driving down sustainment costs. A further challenge for the commercial sector is to expand internationally in undeveloped markets, while the military sector assumes more responsibility for research, development, and production of mission systems that can be leveraged for commercial use. Addition of the MD 500 and 600 series helicopters to the Bell line strengthens their commercial position against

Eurocopter. Boeing has chosen to pursue military-only production after consolidating the former McDonnell Douglas helicopters under Boeing Defense and Space Systems. Sikorsky is attempting to further diversify between military and commercial lines with the introduction of the commercial S-92 Helibus.

Outlook. The rotorcraft industry's long-term outlook is for a slightly improving market. The value of military rotorcraft production for 2006 is forecasted to be \$6.23 billion, compared to the 1997 value of \$3.96 billion. The production of military aircraft through the turn of the century will remain flat. In 1990, 11 rotorcraft models were in development or in production for the US military - by 2000 only four rotorcraft will be in production and only one new helicopter in development. The commercial market will drive the industry as defense budgets continue to shrink and new developmental programs are stretched out.

Figure 2 illustrates the outlook on unit production for military and commercial rotorcraft.

Figure 2:



Source: 1998 American Helicopter Society Annual

The industry remains marginally profitable and overcapacity remains an issue. All three US rotorcraft producers and GKN Westland are small components of larger corporations. Failure to produce consistently reasonable profit margins may force parent corporations to divest, requiring further mergers or liquidation. The merger of Boeing and McDonnell Douglas will help the US market address over-capacity and further define the niche markets of each major manufacturer. Further merging of US manufacturers is unlikely but success in the joint production of the EH101 could logically lead to merger of Agusta and

Westland. Still to be decided is possible alignment or teaming of Russian manufactures with US or European counterparts.

Joint ventures in producing the V-22 Osprey tilt rotor, RAH-66 Comanche armed reconnaissance helicopter, EH-101, and NH-90 medium utility helicopters mark the trend of the future in military development and production. Joint ventures allow for sharing information, engineering, and expertise while lowering the risk to each venture member. Joint ventures also ensure two lines of production and a source should one member leave the venture.

Bell Helicopter's future success is dependent upon the success of the joint venture V-22 and the civilian counterpart Model 609 tiltrotor while maintaining dominance in the commercial light single and multiengine market. Boeing's future success is dependent on the joint venture V-22 and RAH-66 and the continued production/remanufacture of the AH-64D and the CH-47 Improved Cargo Helicopter. Sikorsky remains the US producer at greatest risk dependent upon UH-60 and CH-60 production in the short term and the joint venture RAH-66 and remanufacture of the UH-60 and SH-60 over the longer term. Sikorsky's S-92 Helibus is the unknown that could make up for the company's lack of commercial market share.

Aircraft Engines

The top four engine makers are Pratt & Whitney and General Electric in the US, Rolls Royce in the United Kingdom, and SNECMA in France.

Current Condition. Spurred by the growth of commercial aircraft sales worldwide, the commercial engine market is driving overall sales. Backlogs in foreign and domestic aircraft production will guarantee substantial opportunities in the commercial market. The military engine market – impacted by the contraction of defense budgets worldwide – has fared less well. The F-22, F/A-18, Grippen, Eurofighter, Rafale, and Joint Strike Fighter present limited opportunities for military engine development and production.

The engine market is characterized by high development costs and low profit margins. Consequently, engine manufacturers are looking to the following initiatives to reduce costs and enhance profitability.

- Joint ventures among engine manufacturers (domestic and/or overseas) in order to spread risk and development costs. European manufacturers are aggressively seeking ventures to maintain their share of the critical commercial market.

- Development of derivative engines from a common core to reduce initial development costs. Design modifications include greater thrust and capabilities to improve range, weight and noise reduction.
- Innovative life cycle support and financing options (including lease and “power by the hour” agreements) to expand business base and improve profitability. The manufacturer (domestic or overseas) assumes responsibility for maintenance and for integrating improvements throughout the life of the engine.
- Foreign military sales (FMS) to increase quantities, to reduce unit cost, and to keep military engine programs profitable.
- Quality and statistical process control initiatives in both prime contractor and subcontractor facilities to improve reliability, increase time between overhaul, and decrease support costs.

Challenges. The greatest challenge for engine manufacturers is profitability in an environment of fierce competition. Extremely high development costs (up to \$2 billion), competition, and the long period to realize return on investment (15-20 years) means low profit margin on engine sales and makes the pursuit of new engines a strategic corporate decision. These conditions will demand manufacturing innovation and the development of life cycle support programs.

While US industry maintains a competitive technological advantage in the global marketplace, international competitors are closing the gap. European companies are striving to achieve number one or two in their respective core competencies to keep their niche in the market. Of particular concern is the vigorous competition that is building in the emerging markets worldwide.

Outlook. A growing commercial sector and early retirement of commercial aircraft and engines (for age and future noise/emission standards) will fuel a growing engine market. Dual-use technology should continue to establish a workable system to keep defense contractors viable. Extremely high development costs and the long period to return on investment will force collaboration through joint ventures. Profitability will be found in innovation and total engine support for the foreseeable future. The future for aircraft engines is joint ventures between the major producers and expanding profitability in total life cycle engine support.

OTHER IMPACTS ON THE AIRCRAFT INDUSTRY

Trends in Design, Integration, and Manufacturing

Information technology within the aircraft industry has attained a new level of maturity that is now capitalizing on information technology investments. Today, Computer-Aided-Design/Computer-Aided-Manufacturing (CAD/CAM) software and other information technology solutions are incorporating standard data interfaces that provide for the total integration of design, engineering, analysis, manufacturing, product data management and life cycle support processes—as well as integration across software product lines. This movement towards systems integration is leading to dramatic enhancements in concurrent engineering design processes, consortia approaches in development of new aircraft, engineering design analysis modeling and simulation, tooling and manufacturing processes, and final production. Single CAD/CAM systems are now supporting the total design and development of new systems' integration engineering efforts.

Integrating engineering analysis with product design is becoming extremely important as design problems become more and more complex, and require increasingly sophisticated analysis techniques. Corporations now aim at information technology solutions to develop analysis and simulation models through integration with original 3D CAD design data. The objective is to determine design problems and product design performance earlier in the development phase. Integration of visualization products and digital prototyping software is also leading to the restructuring of design and development processes into large-scale, interactive virtual environments. Prototyping, physical mockups, and certain aerodynamic design testing are now being eliminated in the development process and performed digitally through "virtual design" applications made possible by these innovative, collaborative technology solutions.

The major benefits of advanced information technology solutions are increased corporate productivity, efficiency and competitiveness, and reduced design/manufacturing costs and product cycle times. Further movement toward integration of virtual design applications and leveraging of information technology solutions, as well as restructuring of design, manufacturing and production processes, will continue to be significant in the future. Corporations seeking to maintain their competitive edge will need to continue to focus on integrating design

automation and information technology solutions into their business processes.

Advanced Materials

The vocabulary of the aerospace world includes such terms as super alloys, composites, ceramics, carbon-carbon, memory metals, intermetallic, and metal-matrix composites. Many of these materials are already in use; however, significant advances still lie ahead. While the lure of a promise of greater strength, reduced weight, and increased heat resistance is strong, challenges remain in manufacturing technology and cost.

Metal, most notably aluminum, has been the mainstay of the aircraft industry. New aluminum alloys offer engineers specific improvements over previous materials. The best candidate is aluminum-scandium; a material investigated more in Russia but recently supplied by US producers. It is both strong and corrosion resistant. Another advance in the metals arena includes the use of powdered metal technology. Molten metal droplets are cooled at rapid rates to produce uniformly distributed crystals resulting in alloys which are stronger and have higher melting points. Powder metallurgy offers cost savings due to net shape design and little scrap loss.

The greatest challenge for composites has been to get a better balance between cost and performance. Recent advancements offer progress on both fronts. Improvements in fiber development could lower the price of conventional carbon fiber from the current \$20 per pound to \$3 per pound. Resin transfer molding (where resin is injected into fiber preforms enclosed in heated mold cavities) has emerged as a viable method for producing composite parts. One manufacturer used this process to develop a fan inlet case for an aircraft engine, saving both weight and cost. Another new process involves the use of an advanced stitching machine to join large composite sections together to form an all-composite wing which should lower production costs by 20% and weight by 25% when compared with conventional aluminum construction.

For years ceramics have held great promise for advancement in engine technology because of their ability to withstand high temperatures, but progress has been slow because of problems with brittleness and lack of ductility. Development of ceramics with ultrafine grains shows promise for creating ceramics with metal-like properties. Recently, researchers discovered that hollow ceramic beads originally

made for heat insulation also make a good noise-dampening candidate, offering a way of abating engine noise.

Two promising areas for continued research and development efforts include smart materials and memory metals. Smart materials could improve aircraft monitoring systems, for example through a network of optical fibers or electrical sensors, and warn of cracks or defects as they occur.

The Shrinking Supplier Base

In the last 10 years, there has been a reduction of US aerospace prime contractors and their suppliers due to the downturn of the civil aviation markets in the late 1980s and an overcapacity condition in the defense aerospace business due to the end of the cold war. While the civil aviation markets are currently booming, the military has seen considerable reductions in budgets for procurement, and operations and maintenance. The initial impact, especially on second and third tier suppliers in the early 1990s, was that many went out of business, were bought out by larger companies, or changed to nonaviation product lines. As civil and defense prime contractors restructured and consolidated to become more cost competitive (and reduce overcapacity in the defense sector) more emphasis was placed on the lower tier suppliers to produce higher quality products, on time and at low cost. Since the late 1980s, it is estimated that the supplier base fell from 120,000 firms to around 30,000 firms in 1993. This number could be reduced another 20-25% by 2002 due to defense consolidation and lean manufacturing initiatives. Similar reductions in the European aerospace supplier base have, and are currently taking place.

A recent Deloitte & Touche Consulting Group survey of 67 leading North American aerospace and defense prime contractors and suppliers offers some insight into future trends in the aerospace and defense industry. Most primes plan to continue concentrating purchases and rationalizing their supplier base at an accelerated pace -- particularly defense primes. Both primes and suppliers agree that suppliers who can offer broader integration and more comprehensive systems and solutions will increase their business. Willingness to partner, sharing the investment/risk and build to pre-specified costs are becoming key discriminators by primes when choosing suppliers.

While defense primes continue to rationalize excess capacity acquired through mergers and acquisitions, commercial primes and suppliers surveyed are generally planning to increase manufacturing

capability. Most suppliers surveyed plan to pursue new lines of business, develop strategic relations or merger/acquire in response to recent changes in the aerospace and defense industry.

Suppliers, more than ever, need to partner with customers to remain viable. To support this, suppliers must consider developing the infrastructure to facilitate seamless integration with their prime partner(s) by developing capabilities required to deliver more broadly integrated and more comprehensive systems/solutions. They must also consider proactively pursuing alliances, joint ventures or mergers and acquisitions necessary to develop these capabilities. Those suppliers who survive the industry stakeout will have greater financial strength through enhanced volume, fewer competitors, increased stability, and a more level workload. Based on the Deloitte & Touche survey, the total number of suppliers will continue to shrink, though those who remain will realize a greater share of the total workload and have a more stable relationship with prime contractors.

From a DoD perspective on downsizing and consolidation, there is minimal impact on essential capabilities required for unique military requirements. However, DoD has taken action to sustain key subtier industrial capabilities required to meet current or projected defense requirements. The 1997 Annual Industrial Capabilities Report has identified no vulnerabilities from foreign suppliers in cases where foreign industry is the preferred or economically viable source for suppliers. However, militarized flat panel displays, (Japan has cornered the commercial market on displays) are nonexistent within the US. Government involvement is required in helping the next generation flat panel display industry in the US become economically viable and competitive in the world market place.

With the worldwide consolidation of the aerospace industry, and the use of an international aerospace supplier base for the prime aerospace contractors, the US must ensure suppliers of critical components and materials are not eliminated or fall behind in production capability (surge) due to over commitment. Without a quantifiable, robust, lower-tier supply base, our ability to bring about a surge in supply during mobilization or contingency operations could be at risk.

International Competition

Competition in the aircraft industry is and will remain fierce. Extremely high program development costs and slim profit margins over extended periods make each sale crucial to the business strategies of the

major corporations. Currently, the key to successful sales of aircraft, helicopters and engines involves innovative funding and leasing packages and life cycle support offered at the time of sale. Product reliability and maintenance and operating costs play a significant role in customer decisions but the real driver is price.

Competition between the two major commercial fixed wing aircraft companies will likely intensify as Airbus challenges Boeing's market lead. As late as 1997, Boeing had 55% of the market compared to 45% for Airbus. Although Airbus is still restricted by a cumbersome four-nation consortium, it already has a significant share of the global market and has publicly announced its corporate goal to become the number one commercial aircraft builder in the world. Until recently, Airbus aircraft design and production work share has been split among four nations based on a politically expedient distribution of the workload rather than on best price and efficiency. Should the Airbus consortium be privatized as expected, it will be in a better position to obtain the best prices from available vendors, and its competitive position could improve.

Bell, Sikorsky, Boeing, Eurocopter, Westland and Agusta are the major helicopter manufacturers with no significant shift in market shares anticipated. For commercial products, each company has its own niche market on which it depends. High development costs coupled with relatively low production numbers prevent most of the firms from breaking into the core competency areas of the other industry leaders.

Although competition continues to increase in the aircraft engine industry, there has been no significant shift in the industry make up of General Electric (GE), Pratt & Whitney, Rolls-Royce and SNECMA. Engines continue to be sold at extremely small profit margins, if any, with both American and European engine manufacturers focusing on life cycle support to increase business profits. However, increasing engine reliability has resulted in a declining market for parts and repairs. With narrow profit margins and intense competition, industry analysts believe that three large engine makers is one too many and they expect to see continued emphasis on partnerships between the leading firms. Engine manufacturers themselves agree that the fierce competition hurts them all and that there will likely be an increase in joint ventures and alliances.

Industry Restructure

Within the US aircraft industry, viable consolidation is almost complete while internal restructuring is still underway. Overseas,

neither consolidation nor restructuring has been pursued to their optimal ends. European industry in general is making slow but steady progress toward restructuring and consolidation of both national and transnational corporations as they seek to decrease costs. Governments in Europe still pursue policies intended to prevent the migration of industry out of their countries regardless of the inefficiencies of such policies. The European industrial block is trying to ensure that European firms remain key players in the global economy. When European industry does rationalize its structure, its competitive edge may increase. With an increasingly global economy, international corporations are buying firms in other countries to address issues of reciprocity and to ensure market access.

Consolidation of the European defense industry lags behind the commercial sector. Cooperative efforts like the Eurofighter 2000 have succeeded in rationalizing some manufacturing facilities at the sub-component level. However, national security priorities have prevented shutdown of military aircraft production lines. Despite aggregate defense spending levels less than the US, Europe is currently supporting six separate fighter aircraft assembly lines. In the near-term, it's unlikely this overcapacity will be significantly trimmed. Until then, the US will enjoy a substantial production cost advantage in the military aircraft market.

Extreme competition in the international aircraft industry will continue. Virtually all of the competitors are introducing business strategies intended to incrementally reduce the cost of production while investing heavily in research and development to push their technological edge.

GOVERNMENT GOALS AND ROLE

As the defense budget declines, a strong market focus will be needed to retain world leadership in the military market and to sustain a warm industrial base for potential mobilization. In the aggregate, it is essential to national security and economic prosperity that the government ensures the health of the aircraft industry.

In contrast to booming commercial sales since the mid-1990s, US military aircraft purchases have fallen dramatically over the past 10 years. Many production lines have been closed and remaining programs have been repeatedly cut and stretched out. Plans over the last few years to boost total military procurement from \$40 billion to \$60 billion a year failed to materialize during budget execution. In short, military aircraft

procurement funding has been unstable relative to plans. Research funding for defense-related programs has also declined. The technological preeminence of US industry will erode unless government continues to support research initiatives. Furthermore, government restrictions, sanctions, regulations, and trade laws impact the industry's ability to compete with international manufacturers.

Overall the government's most important aviation industry role is to develop sound defense procurement policies and foster fair trade policies like those that have driven recent record commercial aircraft sales. To pursue these ends further, the government should do the following.

- *Clearly define military aircraft mission requirements and develop a stable, joint, best-fit procurement strategy.* Absent this crucial first step, resulting procurement decisions and industrial consolidation sacrifice rationality.
- *Consolidate military infrastructure to reduce operations and support costs.* The administration faces little congressional support for another round of base closings due to the potential impact on local constituencies and disagreements over past closure actions. These issues need to be resolved so that DoD can reduce excess infrastructure that is driving operations and support costs and draining resources from modernization accounts.
- *Compete depot level maintenance of military aircraft systems, regardless of the parochial objections of government depots and industry.* Benefits include increased depot efficiency, potential new work for industry to offset declining aircraft production, and savings that can be applied to modernization.
- *Promote acquisition reform and dual use technology.* Acquisition reform eliminates government-unique burdens and moves defense managers to commercial standards and practices. This is essential for the integration of the defense industrial base within the civilian economy. With dual-use technology, defense goods benefit from economies of scale in commercial production and domestic manufacturers reap the advantages of military funded R&D.
- *Utilize the contested Lockheed-Martin/Northrop-Grumman merger to define the legal (antitrust) standards for corporate consolidation.*
- *Support foreign military and commercial sales of domestic aerospace products.* US foreign policy initiatives and global diplomatic efforts are needed to sustain and enhance the aircraft industry through offshore sales.

CONCLUSION

The aircraft industry is a mature but evolving industry. Intense international competition and high development costs have driven the industry to consolidate and divest business activities that are not part of its core mission. As a result, the industry has transformed from numerous competitors with a wide range of products to a more concentrated industry with fewer product lines. This concentration has rippled through the subtier levels as suppliers seek to establish preferred supply agreements with the prime contractors, reducing the overall number of suppliers. This process has allowed companies to specialize and focus on their core competencies, thereby achieving economies of scale and reducing production costs. However, there may be hidden costs to customers associated with reduced competition. A narrower supply base also introduces vulnerabilities to commercial contractors, who cannot expand supply quickly in reaction to increases in demand for aircraft. In addition, it may create a vulnerability for DoD, which will have fewer suppliers to rely on to meet mobilization surge requirements. In order to mitigate these vulnerabilities, the government should monitor the industry rationalization process closely to ensure that the resulting structure will meet the Nation's economic and national security interests.

Not only is the aircraft industry becoming increasingly global, the market is becoming increasingly sensitive to international influences such as the east-Asian financial crises. In addition, domestic companies are looking to overseas suppliers and competitors for partnerships and joint ventures to obtain critical capabilities and share risk.

Competition has forced the industry to focus on total life cycle cost of their product. Aircraft customers (i.e. airline companies, leasing companies, and transport companies) must actively contain costs in order to survive. They are sensitive not only to the purchase price of the aircraft, but the cost to operate and maintain it. Manufacturers are offering customers total life cycle support their products as a means of lowering overall costs and risk of ownership. This also provides the manufacturers an opportunity to increase profits while providing incentives for product improvements.

Overall, the aircraft and engine manufacturers know their markets and are responsive to customer requirements. This market awareness should help aircraft manufacturers predict and adapt to changes in customer requirements more accurately in the future.

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BIOTECHNOLOGY

ABSTRACT

The US continues to be the dominant leader in the field of biotechnology. Discovery and innovation have resulted in significant enhancements to our quality of life and contributed considerably to our current economic posture making American biotechnology the benchmark for society. As we enter the next century, our robust economy will continue to be the preeminent pillar of our National Security Strategy with biotechnology playing a key role in sustaining the US economy. However, success within the biotechnology industry does not come without failure. The industry is undergoing a dynamic period of competition, cooperation, and collaboration as it struggles to achieve economic efficiencies. Governments and industry are achieving significant progress, but problems relating to international acceptance, financing, and the more difficult ethical arguments remain.

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PLACES VISITED

Domestic

Biogen, Inc., Cambridge, MA
Beltsville Agricultural Research Center, Agricultural Research Service,
US Dept. of Agriculture, Beltsville, MD
Gene Therapy Inc, Gaithersburg, MD
Genentech, Inc. San Francisco, CA
Genzyme Manufacturing. Allston, MA
Medimmune Inc., Gaithersburg, MD
National Institutes of Health, Bethesda, MD
Thomas Jefferson High School of Science and Technology,
Arlington, VA
Western Regional Research Center, Agricultural Research Service and
Plant Gene Expression Center, Albany, CA

International

EU Roundtable Discussion, Brussels, Belgium
NATO Headquarters, Brussels, Belgium
Pfizer, LTD, Sandwich, England
BASF-LYNX Bioscience Agriculture, Heidelberg, Germany
European Molecular Biology Laboratory, Heidelberg, Germany
Hebrew University, Jerusalem, Israel
Hezera Seed Company, Lakhish, Israel
Intelligene, Jerusalem, Israel
InterPharm Science Based Industrial Park, Ness-Ziona, Israel
TEVA Pharmaceutical Industries LTD, Petach-Tikva, Israel
Weizman Institute, Rehovot, Israel
Moredun Scientific Limited, Midlothian, Scotland
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INTRODUCTION

At the molecular level, plant and animal life are indistinguishable. All are composed of combinations of carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Biotechnology is concerned with understanding the molecular nature of life as well as how that understanding can be applied to improve our quality of life. It exploits this relationship through the recombination of molecules to improve our quality of life. Advances in biotechnology promise new treatments for previously untreatable diseases, increases in crop yield, new methods of healing environmental degradation, and other unimagined benefits. Yet, such advances are not immediate, are costly, and not without potential abuse by others with different views. Biotechnology requires not only scientific understanding but also in-depth consideration of its potential consequences on many aspects of life.

Understanding and manipulating genes through genetic engineering in plants and animals is key to correcting genetic flaws, curing life-threatening diseases, and helping to feed the world through transgenic agricultural research. Better health and greater food supplies could promote regional stability by reducing the gap between the haves and have-nots.

The biotechnology industry study focused on the domestic and international business environment, government and industry interaction with leading biotechnology companies, key military organizations and industrial customers, and research and development (R&D) in this burgeoning field. The group's approach to the study included seminar sessions with biotechnology experts from industry, government, military and academia; independent research projects; and local, domestic, and international field studies.

During the analysis, the study group reviewed the industry's funding and financial status, business practices, marketing strategies, legal and ethical considerations, regulatory issues, patents, international competitiveness, and national security issues.

The group assessed the current peacetime status of the industry and its potential for future contributions to our economic well being and ultimately US national goals. The group also evaluated biotechnology's ability to support requirements during national crises, relative to our national security strategy.

THE BIOTECHNOLOGY INDUSTRY DEFINED

Complex Industry with Significant Economic Potential

Diversity characterizes the biotechnology (also called biotech) industry. Market sectors vary and organizations vary in size, processes, and products. The US is the international leader in spawning, nurturing, and developing biotechnology firms. This industry is small in comparison to other strategic industries. There are over 1,300 biotechnology companies in the US, approximately one-third employing fewer than 50 personnel and more than two-thirds employing fewer than 135 people (Biotechnology Industry Organization, 1998a). By illustration, the market capitalization of the top seven US biotechnology firms is \$30 billion, compared with a market capitalization of approximately \$390 billion for the top seven US pharmaceutical companies (called "Big Pharma").

A Comparison of US Biotechnology Sectors

Major biotechnology sectors, in order of size and importance to the US economy and national power, are healthcare, agriculture, environment, and resources. Clearly, the largest, most economically promising and ethically intriguing biotechnology sector is healthcare. Healthcare can be further divided into concerns with *therapeutic* (bio-engineered medicines/drugs/gene therapy for treatment and prevention of disease or vaccines for immunizations) and *diagnostic* (bio-engineered tools to diagnosis diseases, maladies, and debilitating conditions).

Several years ago, some US industry experts predicted a major shakeout and consolidation in the domestic biotechnology healthcare sector that could result in the demise or acquisition of small and medium firms by Big Pharma. While Big Pharma's appetite for biotechnology companies has remained selectively strong, it is equally true that these smaller firms will continue to be part of the biotechnology landscape. What *has* emerged is a complex, sophisticated, and ever-changing web of mergers, acquisitions, partnerships, strategic alliances, licensing arrangements, and investment strategies.

Agriculture-biotechnology, the second largest biotechnology sector, promises the world increased crop yields, enhanced flexibility in growing environments, reduced pesticide use, and improved nutrition and flavor in food. Because of medical demands, more money has been directed toward biotechnology healthcare research than to agriculture biotechnology applications. However, as population pressures continue

to grow, food availability and distribution will push agriculture-biotechnology more to the forefront of research activity.

Agriculture-biotechnology business planning is proliferating around innovations in natural pesticides, trait-identity-preservation systems, food ingredients, precision farming technologies, and production of low-cost pharmaceuticals. Animal transgenics are also expected to increase dramatically in the coming years with advances in growth and meat quality improvements, and treatment of hereditary disorders (Biotechnology Industry Organization, 1998a).

Industry Concentration

Biotechnology firms have located in geographical areas near related industries and centers of academic excellence. The majority of biotechnology firms have located in California, New England, Mid-Atlantic, and New York/New Jersey/Philadelphia (American Association for the Advancement of Science, 1997). This distribution correlates well with medical mega-centers in Boston, San Francisco, Los Angeles, and the Mid-Atlantic, and pharmaceutical/chemical industries in New Jersey/Philadelphia and New York. It is not coincidental, that San Francisco, Boston and the Mid-Atlantic are also centers of information technologies and higher education, as these are critical enabling and key supporting elements for biotechnology. Biotechnology centers also exist in other areas of the country such as Minnesota, the Pacific Northwest, and in the Research Triangle area of North Carolina.

Biotechnology Companies Beyond US Shores

Biotechnology is not restricted to US shores. The European's progress in biotechnology research was underscored by the birth of Dolly, a sheep cloned from a mammary cell at a research institute in Scotland.

The United Kingdom is the US's leading international competitor. Further, the past year has shown a dramatic increase in the number of European companies. With 741 biotechnology firms, Europe has now just over half as many companies as the US, which is holding steady at about 1,300 firms. This represents a 27% increase from 1996 and a 1% decline from 1997 in US biotechnology firms. Looking at the current trends overall, US firms total 140,000 employees (up from 118,000 in 1997), market capitalization of \$93 billion (\$83 billion in 1996) and revenues of \$17.4 billion (up 19% in 1997) as compared with about 30,000 employees and \$1.7 billion in revenues from European firms

(Ernst & Young 1998). Clearly, while European biotechnology is growing, it is not yet comparable in size with the US market. Other regional markets are even smaller, including Israel, which has 70 firms and employs fewer than 10,000 people.

Impact of European Economic Union (EU)

Clearly, the most significant economic development in Europe affecting US competitiveness in all industries, including biotechnology, is the growth of the EU. This trend is resulting in the coalescence of EU responsibilities and authority regarding regulatory processes for new drug approval, patenting, marketing and pricing.

For example, recent changes in the EU regulatory system mandate that all biotechnology drugs be approved through a centralized process managed by the European Medicines Evaluation Agency (EMA), which was established in 1995. The EMA, which is the EU equivalent of our Federal Drug Administration (FDA), performs project management of new drug applications, and coordinates inspections, safety, scientific and political issues arising from the approval process among the 15 member states. The scientific aspects of this process are largely performed by the EMA Committee on Proprietary Medicinal Products (CPMP), a 30-member body comprised of two members from each state in the EU. The CPMP delivers a scientific opinion to the EU Regulatory Commission, an 87-member body, which incorporates health policy, political, and scientific information into its approval decision.

This process, while providing benefits of harmonizing authorization, pricing, and labeling across EU member countries, has also created concerns about drug approval time lags, compared with US FDA approval time lines. The relatively shorter new drug approval timelines in the US, in comparison to the EU, provides a competitive advantage to US firms.

Furthermore, the EU policy of "no free pricing," i.e., pharmaceutical prices are set by the EU vice the market. This policy hurts the market competitiveness of EU firms. Nevertheless, despite these negatives, the European biotechnology industry represents a growing challenge to future US preeminence.

Changes in the European Patent Office and proposals to reduce the cumbersome regulations show great promise in nurturing this neophyte industry. As further evidence of growth, 30 publicly traded stocks have emerged in 1996 on the EASDAQ (modeled on the US-based NASDAQ). This provides small companies capital access and permits liquidity for early investors (Burrill, 1997). Across the European

landscape, Britain remains at the forefront of the European biotechnology industry, accounting for 75% of all European public offerings (Ernst & Young, 1998).

CURRENT CONDITION

A Rapidly Changing and Robust Industry

Biotechnology is one of the highest risk, research-intensive, knowledge-based industries in the world. This industry has evolved into a \$17.4 billion industry within 25 years. It has arguably become one of America's premier industries for discovery and cutting edge innovation. Biotechnology has the potential to function as a dependable engine for creating and sustaining the robust national economy required to maintain our status as the global leader.

At present, the biotechnology market is extremely competitive with each firm vying for available capital. The US position as the global leader in this field is directly attributable to the American culture: entrepreneurship, innovation, excellence in science and technology, and public and private funding of R&D.

Patents Are a Measure of Progress

Patents and licensing agreements are the tools used by government and industry to protect their investments in biotechnology research and production. Government and/or university research successes are patented by the government and brought to the marketplace through licensing agreements with industry. Traditionally the licensing fees have been reasonably priced and, as a result, industry has been quick to market the technology.

Two recognized strategies exist for measuring productivity of the highly concentrated R&D industries: Patents and Important Process Innovations. Patents are among the first and most important benchmarks of progress in developing a new biotechnology breakthrough. They offer limited protection against commercial intrusion by industry competitors. Patents are critical to raising venture capital, the lifeblood of biotechnology R&D.

The US Patent and Trademark Office (PTO) experienced a 58% increase in patent submissions from fiscal years 1991-1996. Given such demand, the PTO increased the number of biotechnology patent examiners from 67 to 184. This increase in personnel helped to reduce the patent application backlog and was funded by user fees.

Innovation is the Key to Success

The innovation in core technologies for the biotechnology industry took a quantum leap in the mid- to late 90s allowing significant breakthroughs in basic research. These highly prized technologies include gene therapy, combinatorial chemistry, genomics, high-throughput sequencing, high-throughput screening, and bio-informatics. These technologies are continuously being refined and applied with unprecedented efficiency to identify genes; map their composition; and establish practical connections between these genes, the protein they encode, and the gene's role in the mechanism of cell function.

These technologies served to create a pattern of stability that formed the foundation of public and private trust necessary to attract adequate amounts of venture capital (Ernst & Young, 1997). Venture capitalists focused their support in the areas of diagnostic tools and procedures, therapeutic protocols and agricultural advances.

This high-risk business has had major disappointments, but has also garnered huge rewards for getting to the market first. Biotechnology companies are mostly small, yet it costs \$200 million to \$500 million and takes from 10 to 15 years for a product to move through the drug development and FDA approval process to profitability (Biotechnology Industry Organization, 1998). These firms must therefore work in "coopetition" (cooperation while in competition) to be economically viable.

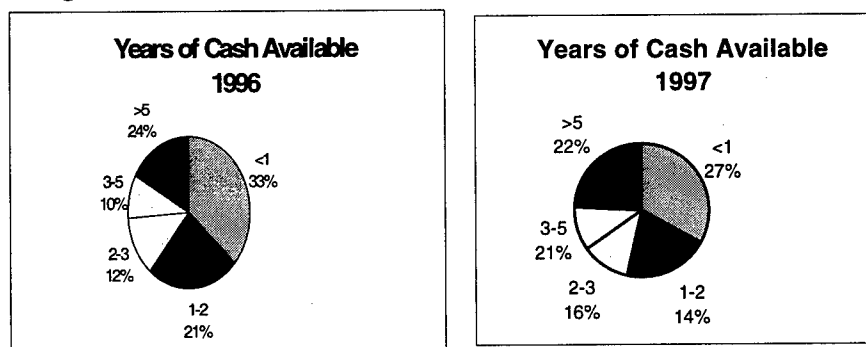
Revenue Trends Over the Years

In their early years, biotechnology companies spend huge sums on R&D, with small finance and administrative staffs — and generate little or no revenue. As they bring products to market, R&D occupies a shrinking portion of their costs, with sales, manufacturing, marketing, and legal costs increasing. On average, biotechnology firms expenditures are now 55% R&D (down from 72% eight years ago), 10% marketing, and 19% manufacturing.

The industry as a whole experienced a 20% increase in sales in 1997 with the strongest growth in the therapeutics sector. Biotechnology firms have commercialized more than 50 products, but only four biotechnology drugs are in the top 50 (Standard & Poors, 1998). However, there are 500 products in clinical trials. As a result, 20 to 40 companies could soon start generating revenues and earnings. Yet, the vast majority of the 340 publicly traded biotechnology companies are still years, if not decades, away from profitability.

At the end of 1996, public biotechnology companies had \$20.1 billion in assets (up 20% from the year before), including \$3.2 billion in cash and cash equivalents. As shown in figure 1, cash on hand increased to a healthier level in 1997, over 1996. Liabilities totaled \$6.5 billion (up 14% from the year before), including \$2.5 billion in long term debt.

Figure 1: Years of Cash Available 1996 and 1997



Thus, stockholders equity was \$18.3 billion, an increase of 38% from 1996 (Ernst & Young, 1998). Only 3% of biotechnology companies are making money right now, but by 2010, 70% of our economy is expected to be affected by the industry. While industry analysts differ in their positive predictions about the future, the upward trend toward higher and higher profitability is clear.

Biotechnology and the Information Age

Information Technology (IT) has served to accelerate the advancement in biotechnology in several ways. Many companies use IT as a critical part of their process. Modeling and simulation of molecular interactions and high speed screening of molecular alternatives are only two examples. Other firms use IT in support of the process. Data management, organization, storage and retrieval are their primary requirements. The common use, and probably the most important contribution of IT to the advancement of biotechnology, is the ability to communicate findings and data almost instantly with colleagues located worldwide.

A recent important advance in this relationship was the development in 1996 of the biochip or DNA array technology. This has the potential to give medical researchers the ability to analyze thousands of genes at once. This means that chips may be constructed to look at individual

blood or tissue samples for specific genes of families of suspect genes that are suspected of causing, say, breast cancer. If the genes are noted in the sample, then early aggressive treatment may be undertaken well in advance of the onset of the disease. For instance, it may be possible within the decade to put a few of an individual's cells in a gene-chip scanner and quickly analyze his or her genetic risks for diseases. Although IT has increased the capability of this industry to perform a greater volume of tests within a shorter period, the regulatory imposition of additional tests has negated the expected timesaving.

Globalization Trends Predict a Prosperous Future

Companies dedicated to developing treatments for cardiovascular, neurobiological, and cancer-related illnesses enjoy the highest capitalization. The largest firm in the biotechnology industry, with a market capitalization of \$15.4 billion, has true global reach. It has 5,400 employees worldwide with production and manufacturing facilities in the U.S and Puerto Rico, and an international sales force in Europe, Asia, Australia, and Canada.

Complex Production Process Can Lead to Profits and Losses

Being a high risk, venture capital intensive industry, the larger and most successful companies often choose to boost their productivity by teaming with smaller biotechnology firms. These smaller firms have highly qualified and trained scientists, but not the financial capital to pursue costly and high-risk research and development ventures. Because of the lengthy process before a product is brought to market, the government, via grants to universities, government labs, and other nonprofit institutions has been a significant source of funding for research and development in the biotechnology industry.

CHALLENGES

To capitalize on the potential benefits that biotechnology can bring to humankind, basic research must be encouraged and its discoveries expeditiously transferred from the laboratory to the marketplace. Conventional thinking assumed that the government, with universities, would assume responsibility for nurturing basic research, and the commercialization of research breakthroughs would be accomplished by industries. Reality is not quite that simple or cooperative.

Intellectual Property Protection

The cost to take basic research to commercial application may be up to 100 times the initial expense of the basic research. Patents and licensing agreements are the tools used by government and industry to protect their investments in biotechnology research and production. Federal laboratory research successes are patented by the government and transitioned to the marketplace through licensing agreements with industry. Traditionally the licensing fees have been low to ensure efficient transfer of the technology. US industry has been quick to market the technology

Open access to technological breakthroughs is another challenge facing the biotechnology industry. Restrictions and proprietary entitlements can make the transition from research to commercial application cost prohibitive. Consequently, commercialization is either severely delayed, or, worse, shelved. To ensure a strong future for the field of biotechnology, the US needs to expedite patents, promote cross-licensing agreements, and work to create close cooperation and communication among federal laboratories, universities, and industry.

Within the US, observance of intellectual property rights and litigation to resolve such disputes are well-established business practices. Because the biotechnology industry's products are intellectual in nature, patent protection and licensing agreements remain vital to the industry's survival. The biotechnology industry will be increasingly challenged by the need to codify and enforce intellectual property statutes while stimulating efficient scientific progression.

The US patent process is complex and prone to generating litigation if a comprehensive examination is not properly executed. There are several initiatives underway to improve the dispute resolution process. These initiatives, inside and outside the judicial system, may expedite the introduction of new technology into the marketplace.

Moral and Ethical Issues Coming to the Forefront

The frenetic pace of discovery in biotechnology research and applications may be subsumed by the depth of the moral and ethical dilemmas those very discoveries pose. Consider the following areas of concern: cloning; manipulation of plant life to improve production and increase resistance to disease; genetic privacy, keeping insurance companies from denying coverage based upon genetic markers; and patenting an entire genome. Such issues raise many questions.

Do you own your own genes? If a researcher provides you with informed consent and goes on to develop a cure for cervical cancer, based upon your cell line, should you share in the profits? Should we continue to grant patents for specific genetic markers as they are discovered? If your unborn child is determined to have a genetically based disease, is it right to treat the child in the womb through transfer of corrected genetic material? Should parents choose the genetic attributes of their future child? Given that the list of issues is endless, what can be done to come to grips with these issues?

The moral and ethical issues in genetics and biotechnology are capable of being effectively evaluated by the public. The industry is actively pursuing education of the media and the public through the use of lectures and focus groups. More importantly, public discussion is required. Such discussions should include, as a minimum, representatives from the clergy, scientists, lawmakers, and members of the public at large. This public dialogue will help shape the hard decisions that lie ahead as we attempt to strike a balance between the fruits of scientific research and our internal moral compasses.

Financial Challenges

The biotechnology industry obtains its financial resources from multiple sources including government grants, private venture capital, initial public offerings and follow-on offerings, alliances and corporate partnerships, and mergers. Financing biotechnology companies is a risky business. A biotechnology company expends huge sums of cash as it strives to push new products through R&D, clinical testing and the multiphase FDA approval process.

This process is lengthy and costs millions of dollars, during which time there are few sources of revenue, intense competition, and no guarantees of success. Few start-ups succeed because they must navigate a long, perilous road: products that fail in clinical testing, stock prices that plunge just as the need to replenish cash is the greatest, patent snarls, and FDA delays. Furthermore, company insiders are forced to sell their equity, thus diluting their own holdings—or to sell promising research or potential products to raise cash. Cash equates to survival; keeping a biotechnology company in cash is a firm's most daunting task.

European Union

Europe poses a challenge for the US biotechnology industry in expanding its market. The EU has increased cooperation among member

countries and has coordinated an existing powerful network of political interest groups, which favor small farmers, strong government subsidies, and an anticorporate climate. Because of adverse publicity, such as Mad Cow Disease, the biotechnology industry has been more politicized resulting in reduced confidence, by the European public, for the safety of food supplies and adequacy of regulation. These issues must be overcome if the US is to succeed in gaining public trust and acceptance, and convincing new markets that biotechnology products offer more nutritious, healthier, and cheaper products.

OUTLOOK

Investing in Science Promotes Economic Prosperity

The 1994 National Science Policy Report pointed out that the return from our public investment in fundamental science has been enormous. The principal sponsors and beneficiaries are the American people. Our scientific investments are an important national resource to be sustained and built on for the future. Technology is the engine of economic growth; science fuels technology's engine. Over the long-term, US investment in fundamental research must be commensurate with our national goals (White House, 1994).

Continued Quality of Life Improvements

What will biotechnology mean to investors in the next century? Some would argue that due to continuing biotechnology advances, most cancers; many genetic diseases; and Parkinson's, Alzheimer's, AIDS, and other infectious diseases will eventually be controllable or eradicated. An official from a major biopharmaceutical merchant bank explains the biotechnology revolution that is taking place. He claims that a biotechnology revolution—similar to that in the semiconductor and chip market of the last 15 years—is inevitable.

Within 20 years, 25-30% of the population will be 65 or older (Financial Mall International). Improving the health of the aging baby boom generation presents biotechnology firms with great opportunities for commercial successes. The combination of new-company formation, growing average company size, and new technologies will ensure that the industry continues to advance.

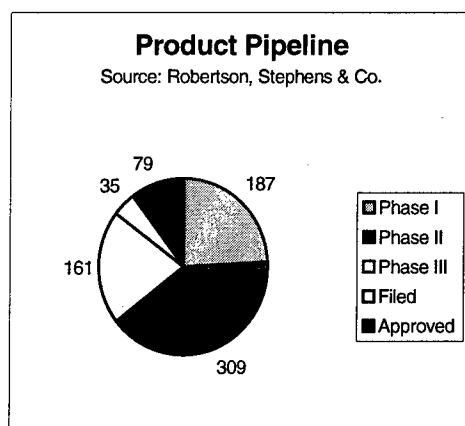
With so many companies vying for financing to capitalize on their discoveries, consolidation increases. Advances in R&D will spur more competition among biotechnology and Big Pharma companies,

increasing the likelihood of mergers, which are a means by which large pharmaceutical companies can reduce financial risk. It is projected that increased R&D spending, will result in a substantial increase in new drug approvals and productivity trends.

The 1999 federal budget includes a "Research Fund for America" that ramps up federal assistance to \$38 billion by 2003. This includes an "unprecedented commitment to biomedical research" in the form of \$14.8 billion, increasing to \$20 billion by 2003, for the National Institutes of Health (NIH). One of the federal government's goals is to complete the Human Genome Project by 2005 and to develop an AIDS vaccine by 2007.

Of the 771 products in the approval pipeline at the end of 1996 (see Figure 2), 30% were for cancer-related products (Ernst & Young, 1996). Cancer killed 6.3 million people in 1996, a number that is expected to double in the next 25 years. Fortunately, major advances in the techniques used to test rapidly how various substances affect the genes, especially those damaged by disease have greatly reduced R&D times.

Figure 2: Product Pipelines



The Future of Biotechnology is Promising

The US biotechnology industry is well structured to lead in this exciting global market. All evidence indicates the industry is on the verge of a new frontier, especially in genetic research, which holds great promise for solutions to once considered incurable diseases and human defects. The key is research, and research depends on a continuing

stream of public and private financing. Financing can be obtained if the industry continues to demonstrate the potential for revolutionary discovery and technology transfer as it has over recent years. A company with a solid management team, vision, and competitive business strategy to bring its product to market will prosper in the end—for the benefit of all humankind.

GOVERNMENT GOALS AND ROLE

US National Security - The Top Priority

Government involvement in the biotechnology industry has been concentrated in three major areas: support for R&D, regulation and oversight, and biochemical defense. Government involvement in basic research, intellectual property protection, regulation, and oversight of the industry has been pervasive and essential.

Although industry has raised funds for product development and testing, much of the basic research has been accomplished at government expense. Funding for basic research has been a government role since the genesis of this strategic industry. The current practice involves a variety of methods to support R&D: intramural research; extramural grants to universities and individual researchers; cooperative agreements with industry; licensing of government patents to industry; and tax incentives, such as those for orphan drug production.

Intramural or in-house governmental biotechnology research facilities exist in the Departments of Defense, Agriculture, Energy, Health and Human Services and other federal agencies. These efforts, particularly at NIH, and the US Department of Agriculture's (USDA) Agricultural Research Service, has resulted in a variety of patents. The basic research by these federal agencies builds on continuity of effort and stability in the agency workforce.

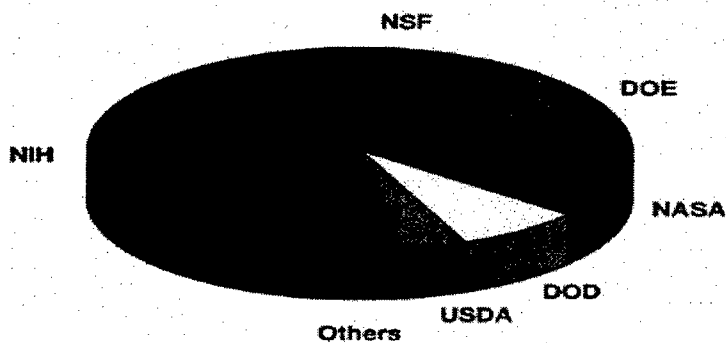
Extramural grants for biotechnology research comprise a substantial portion of the federal R&D budget. These grants also include Cooperative Research and Development Agreements, the Small Business Innovation Research Program, the Small Business Technology Transfer Program, and the Advanced Technology Program.

Basic biomedical research, funded through NIH, accounts for nearly half of the 1998 fiscal year federal basic research dollars. When the funds expended by the National Science Foundation on biological research unrelated to human disease are included, the total is nearly half the Federal research budget (see Figure 3).

Figure 3:

BASIC RESEARCH FUNDING BY AGENCY

FY 1998 Budget Request \$15.3 Billion



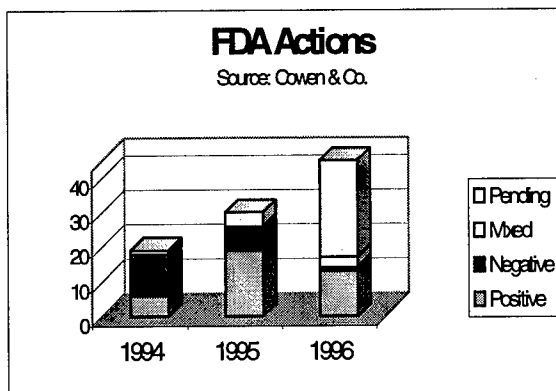
Source: Office of Management & Budget

Funding of basic research pays significant dividends in terms of enhanced competitiveness and economic growth. Agricultural research, for example, contributes to national security, public welfare, economic development, quality of life, and the future of the nation. Advances in science and technology have accounted for up to half of all gains in US productivity throughout much of this century. Basic government-funded research focuses on broad-based benefits that are difficult to measure, and thus unlikely to secure private funding in a market economy.

Regulation Bureaucracy

After a 3-year review, Congress finally approved a comprehensive FDA reform package in October 1997. This reform legislation was brought about by improved cooperation between the biotechnology industry and FDA, promoting a more prompt and effective approval process. It also helps the industry in recouping its capital investment more quickly. The package includes a 5-year extension of the Prescription Drug User Fee Act, which generates funding for 600 additional FDA reviewers, fast-track approval, and other reform measures sought by industry (see Figure 4).

Figure 4: FDA Actions



Source: As cited in Ernst & Young. 1996. "Biotech 97 Alignment," p. 18.

The 1998 Budget Authorization Bill secured a number of tax and investment incentives for biotechnology industry research, including an extension of the R&D tax credit for the Orphan Drug Program and a broad based capital gains incentive for direct investment in biotechnology. The tax incentives are expected to result in an influx of \$10 billion directly to biotechnology companies over the next 10 years.

The biotechnology industry is pervasively regulated. FDA, the Environmental Protection Agency, and USDA all promulgate regulations that affect the industry's ability to produce and market a product. These organizations have different and sometimes overlapping roles. For example, genetically engineered animal growth hormones are under FDA, not USDA, regulation.

Attempts to address product safety and efficacy have effectively increased the length of the FDA approval process and thereby raised the cost of drug development. The PTO also exercises a significant degree of control over the industry in determining what can be patented and how broad patent claims will be treated.

The partnership between industry and the FDA expends one billion dollars a year to regulate the development of drugs, vaccines, food additives, and new foods. The cumbersome approval process was streamlined by new legislation in 1992, which was renewed for an

additional 5 years in 1997. Additionally, the 1997 legislation permits FDA to contract out the review process to expedite new technologies into the market.

Workforce Skills

The biotechnology industry draws on the full range of our educational system, requiring leading edge skills from mathematics and science. Research skills, in particular, are the common denominator across all sectors of the industry. During the start-up research phase of new biotechnology companies, the workforce is heavily skewed to employees with masters or doctorates. A Ph.D. is generally required for independent research while a master's degree may be sufficient for jobs in applied research or product development. At the low end of the workforce are entry level lab technician positions that may be filled by high school graduates with lab experience, but more commonly by those with an Associate or Bachelor of Science degree.

Biotechnology companies are particularly vulnerable in the initial research phases leading to patents. During this phase, most companies focus on recruiting top level scientists with advanced degrees and very specialized skills. As companies mature, obtain patents, and move into product development and marketing, a workforce with broader skills is required.

The prognosis for biotechnology is good, with projected faster than average job growth for biological and medical scientists. Despite this projection, stiff competition is expected for research positions. Tighter federal budgets will continue to result in fewer dollars going to R&D, slowing the number of grants awarded. With the number of newly trained scientists on the increase, all scientists will experience greater difficulty in winning and renewing grants. Another effect of a smaller federal budget is downsizing of federal agencies. With one in four biological scientists working for federal, state or local governments, additional downsizing could affect research jobs and basic R&D projects. In the agricultural sector, replacement of scientists who retire will account for more job openings than projected growth. For chemists, the greatest job opportunities are projected for pharmaceutical and biotechnology companies.

Overall, there appears to be a healthy labor pool to meet the needs of the industry. The number of foreign citizens, who account for an increasingly large number of graduates with math and science degrees, is unknown. Foreign nationals will increasingly compete for positions in the US labor market. Biotechnology firms could become training

grounds for the world's industry, but could encounter higher than normal turnover rates if these foreign nationals return home. There is also concern that propriety information and technology, if not patented, may also leave American shores.

Biotechnology Considerations in National Defense

The government's role in biotechnology defense has become a matter of increased concern as threats to national security from terrorist and rogue states have emerged. Bioterrorists are significant threats as they have access to and a willingness to use weapons of mass destruction (WMD); they cannot easily be deterred by threats of retaliation; and they don't respect boundaries. Additionally, there are more than 25 countries pursuing chemical-biological weapons development programs.

In response to this increased threat, the US, through the Department of Defense (DoD), has concentrated priority efforts on R&D, consequence management, and force protection. R&D efforts focus on improving detection methodologies and equipment, and force protection equipment. There are many products in the acquisition process that will provide an enhanced capability. Regarding vaccines, all troops are being vaccinated against anthrax in response to the current threat. Furthermore, funding was provided for a robust R&D program aimed at the production of additional vaccines and therapeutic drugs. The biotechnology industry is a critical component of this effort.

The DoD and Civil Sector Partnership

The US has recognized the challenge to protect its borders from a terrorist attack. DoD chemical and biological incident response teams are providing training to emergency response personnel in 120 US cities over the next 5 years and providing additional capability through the Army National Guard (ANG). Ultimately, chemical/biological response in support of the Federal Emergency Management Agency (FEMA) will become the responsibility of ANG.

Impact of Declining Defense Funds

Defense funding is continuing to decline in the US and Europe while remaining stable in Israel. Therefore, it is reasonable to expect an increase in collaborative efforts, the transfer of defense technology, vaccine development, and standardization of chemical and biological protection and detection equipment between the US and its allies.

Additionally, small businesses are vulnerable to changes in defense spending and may be unable to meet surge requirements. Inventory levels of protection and detection systems are lower than authorized acquisition levels and do not meet force requirements. The ability of the industry to respond to short-notice production and fielding capabilities remains problematic due to the paucity of suppliers and the lack of a commercial market for much of the equipment. The increased international focus on WMD and uniformity of force protection measures could result in the creation of an international market for WMD defense technologies and equipment.

CONCLUSION

Biotechnology is a strategic industry that will continue to grow significantly during the 21st century. The various industry sectors, i.e., healthcare, agriculture, environment, and energy, provide significant contributions to national security. R&D of genetically engineered animal, human, and plant organisms continue to improve the human quality of life. National defense concerns from biotechnology-related threats are being addressed via research on vaccines, detection systems, and force protection equipment.

Although human and capital resource concerns will persist, biotechnology is expected to be a competitive job sector in the next century. The possibility exists, however, that the US may experience a lag in the number of students seeking degrees in biotechnology-related fields. Currently, companies are locating in resource-rich geographic areas, near educational and IT firms. Scientists are attracted to these companies due to their stable financial profiles. This has resulted in the creation of nodes of productivity and economic prosperity.

Resources are the key concern for today's biotechnology industry. Research areas, the driver for the industry's growth, are typically selected because of concerns identified by individuals or groups. Research selection should represent a planned, national and/or international consensus and prioritization. National security research and improved quality of life priorities can be mutually supportive.

Other areas of concern will also continue to gain visibility. Biosafety concerns will gain momentum and should be addressed through international organizations. Regulatory issues that currently dominate the cost of new developments, must be resolved if the industry is to continue its drive toward production of new and better drugs. International competition for dollars, trade, and scientists, and the commercial biotechnology company's dilemma of taking care of its

shareholders versus its obligation to the international community may change the focus of biotechnology research.

Overall, the industry has shown itself to be motivated and resilient. This small, but quickly growing industry stands poised to be a major player among strategic industries.

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CONSTRUCTION

ABSTRACT

The construction industry is the nation's largest manufacturing sector. It experienced its seventh year of growth in 1997. Competition is extremely keen both at home and abroad with many small firms and a few large, globally competitive firms at the top. There is continued consolidation among mid-sized firms as larger firms have adopted acquisition and diversification as a strategy for growth. Globally, despite the economic slowdown in Asia, the US remains competitive on the strength of its design and management firms and their use of information technology and innovative construction methods.

Our nation's infrastructure remains in need of critical repair and expansion. With the advent of balanced federal budgets, there is a growing willingness to fund these projects. Privatization and Design-Build-Operate variations are also keys to funding this development. Firms that can bring risk sharing, financing, and engineering expertise to the table will retain a competitive advantage. Technology advancement is necessary to keep costs in check in overhead and construction.

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LTC Joseph Fontanella, USA
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Ms. Doreen Harwood, NSA
Mr. Jay Jordan, DAF
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COL Abdullah al-Menji, Oman Air Force
Lt Col Max Della Pia, USAFR
Mr. Norman Reich, OSIA
Lt Col Cardell Richardson, USAF
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Lt Col Jonathan Wohlman, USAF

Dr. Hugh Conway, Dept of Labor, Faculty
Mr. Jeffrey High, Dept. of Transportation, Faculty
LTC Gary Berry, USA, Faculty

PLACES VISITED

Domestic

Associated General Contractors of America, Washington, DC
Boston Harbor and Central Artery Tunnel Projects MTA, Boston, MA
CSR Rinker Cement Plant, Miami, FL
Design-Build Institute of America, Washington, DC
Everglades Environmental Control Project, USACE, Ft. Lauderdale, FL
Everglades National Park, Dept. of Fish and Wildlife, Ft. Lauderdale, FL
Jacksonville Port Authority, Jacksonville, FL
National Association of Home Builders, Washington, DC
Parsons Brinkerhoff, New York, NY
Port Authority of New York, World Trade Center, New York, NY
Raytheon, Boston, MA
Ronald Reagan Federal Triangle Building, Washington, DC
Sheet Metal Workers- Local Union #100, Suitland, MD
Stromberg Sheet Metal Works, Beltsville, MD
Universal Studios, Orlando, FL
US Army Corps of Engineers District, Jacksonville, FL
US Army Corps of Engineers, Dam Projects, San Juan & Ponce, PR
USMC Prepositioning Facility, Blount Island, Jacksonville, FL
USN Field Station Kunia, Oahu, HI
Walter Reed Army Institute of Research, Washington, DC

International

Center for Environmental Technology, Kowloon, Hong Kong
Chek Lap Kok Airport, Hong Kong, China
Cheung Kong Center Construction, Hong Kong Island, Hong Kong
Environmental Protection Department Office, Wan Chai, Hong Kong
Hong Kong Polytechnic University, Kowloon, Hong Kong
Hong Kong Productivity Council, Kowloon, Hong Kong
American Embassy School, New Delhi, India
Asian Development Bank, New Delhi, India
Center for Economic Research, New Delhi, India
Federation of Indian Chambers of Commerce & Industry, New Delhi, India
Fluor Daniel India, New Delhi, India
Raytheon International Inc., New Delhi, India
Yamuna Bridge, Larsen & Tobro, ECC Construction Group, New Delhi, India
International Airport, BIS-Honeywell Consortium, Kuala Lumpur, Malaysia
Light Rail Transit System, HSSI-Halcrow-de Leuw, Kuala Lumpur, Malaysia
Petronas Twin Towers and Menara Tower, Kuala Lumpur, Malaysia
Petronas-Conoco Oil Refinery, Malacca, Malaysia

INTRODUCTION

The construction industry provides our national infrastructure—for our economy, our government and our society. It is the foundation for our ability to generate and sustain the elements of national power. In the broadest sense, a healthy construction industry is an expression of public confidence and national will.

The purpose of this study was to assess the current health and long-term outlook of the US construction industry, both domestically and internationally. To do this, the study group sought answers to the following questions. Is the construction industry able to compete globally and successfully face growing competition in the lucrative American market? What are its strengths and limitations and what is the industry's impact on national security? What are the challenges facing the industry in the near and long-term?

The study group interviewed government officials and industry professionals; visited technical and trade associations and unions and their training components; and evaluated privately-held and publicly-traded corporations. During international visits, the study group saw where and how US construction firms were competing successfully and observed the intensity of their international competition.

This report summarizes the study group's findings on the status of the industry, its challenges, its future and the evolving role of government in the construction industry.

THE CONSTRUCTION INDUSTRY DEFINED

General. The construction industry is the nation's largest manufacturing sector and is expected to grow to \$600 billion in 1998. It is an industry of incredible diversity, fragmentation, and contrasts. Consequently, any assertive generalizations on industry-wide projections and trends can be problematic. The construction industry consists of residential home-building, commercial building, development and construction of infrastructure, construction materials, and construction services—all have unique as well as common characteristics and these are not necessarily mutually reinforcing. What may be a good indicator for one may be the opposite for another.

Structure. The construction industry consists of three broad categories: building construction, heavy construction, and specialty trade construction.

- Building construction by general contractors or by operative builders (dwellings, office buildings, stores, farm buildings, and other building projects).

- Heavy construction (highways, bridges, pipelines, sewers and water lines, marine construction, power, and petrochemical plants).

- Specialty trade construction (plumbing, painting, carpentry, electricity, bricklaying, and roofing).

Firm size. In 1992, there were 1.9 million construction establishments in the US; 572,851 of them had employees. Most firms (80%) had fewer than 10 employees. About three fourths of the firms were sole proprietorships, one fifth were corporations, and the remainder were partnerships. Corporations accounted for 84% of construction business. (Most of the statistics cited are from the *Census of Construction Industries* (Bureau of the Census, 1992)—the latest published.

Labor force. According to the *January 1998 Employment and Earnings Report* of the Bureau of Labor Statistics, construction employs about 5% of the US labor force, but only 1% of its women. The industry consists of 91% men and 9% women. Minorities (African-Americans and Hispanics) represent only 7% of all construction employees.

CURRENT CONDITION

The construction industry is undergoing significant changes in response to new market forces.

Globalization. Traditionally, the construction industry has been predominantly national in its outlook. However, international markets have now become a major source of revenue for large US firms and the object of strategic focus for long-term growth and profitability. Although foreign firms have not made much of a dent in the American market, the sheer volume and value of US construction business will increasingly attract international competitors. At the same time, there will be a much greater reliance on joint ventures and strategic, long-term alliances to facilitate market access and to share risk.

Consolidation. Mergers and acquisitions have emerged as principal strategies for growth and sustained profitability. The rate of economic growth, increased competition, and the abundance of investment capital will continue to spur industry rationalization and consolidation.

Innovation. The changing nature of the market structure and its operating environment are driving significant innovations in project

management and delivery, infrastructure operation, financing, and insurance.

The role of government. A significant shift, from the public to the private sector, is occurring in responsibility for infrastructure development and operation.

Macroeconomic Factors

This is the seventh consecutive year of growth in the industry. Many positive macroeconomic factors drive industry strength: continued growth in the US and world Gross Domestic Product (GDP), a low and stable rate of domestic inflation, low interest rates in the US, and improved fiscal performance by American government. Consumer, investor, industry, and government confidence is robust and there is considerable potential for further growth in the residential, commercial and public sector markets. In particular, the improving fiscal health of government has created opportunities for infrastructure development, particularly in transportation, education, and federal institutions.

There are, however, a few dark clouds on the horizon. The domestic scarcity of skilled labor may have an inflationary effect on the cost of construction. The Asian crisis has dampened the phenomenal rate of growth in construction in that region. Inflation poses a significant risk for construction in some foreign markets, and there continues to be national and regional protectionism in major infrastructure undertakings abroad.

Construction Spending

The US is one of the leading construction markets in the world. Its value represents about 7% of the GDP. The US accounts for about 20% of global construction spending and employs 7.2 million Americans. Table 1 presents statistics for construction spending from 1994-1996, estimates for 1997, and projections for 2001.

In 1995, new construction accounted for about 65% of the industry's business. Although new construction spending is well below its 1966 peak of 11.2% of the GDP, recent years (such as 1994 and 1996) have shown a rebound of new construction spending. Although spending in some facets of construction has flattened or dipped slightly, the future looks bright. New infrastructure legislation and a hardy economy suggest that US construction spending will be steady and strong in the near future.

Table 1: New Construction Put in Place, 1994-2001
(billions of 1992 dollars)

TYPE OF CONSTRUCTION	1994	1995	1996	1997 (Est.)	2001 (Proj.)
Private Residential	217.9	207.4	216.9	210.0	246.0
Single-family	140.4	127.1	134.7	128.0	156.2
Multi-family	12.8	15.7	17.0	16.1	17.8
Home Improvement	64.7	64.6	65.2	65.9	72.0
Private Nonresidential	150.1	155.6	160.2	161.0	167.4
Manufacturing	26.8	28.9	26.9	27.4	31.2
Office	20.6	22.6	21.7	21.9	21.7
Hospital/Institutional	11.4	10.0	10.0	10.2	11.6
Commercial	39.1	44.2	49.3	47.3	46.5
Electric Utilities	13.9	11.8	12.2	12.6	14.1
Telecommunications	9.8	9.8	10.3	10.8	11.9
Other	28.5	28.3	29.8	30.8	30.4
Public Works	119.9	123.6	125.0	126.8	134.5
Highways	36.5	34.9	34.9	34.6	36.7
Educational	21.7	22.9	24.3	25.7	26.8
Other Public Buildings	18.4	19.8	20.4	21.2	22.5
Misc. Public Structures	10.8	11.5	11.5	12.1	13.3
Sewer Systems	9.5	9.9	10.1	9.7	11.1
Water Supply	4.9	5.4	5.6	5.8	6.5
Military	2.2	2.7	2.7	2.5	2.3
Other	15.9	16.5	15.1	15.3	15.2
Total Construction	487.9	486.6	502.1	497.8	547.9

MacAuley, P. 1997. *Construction Review*.

Commercial construction spending in 1998 will flatten (less than 1% due to a decline in retail construction) to \$92.8 billion. The market is generally in good health and early signs suggest that it will swing back in 1999. This follows an estimated gain of 7.7% in 1997 with spending at \$93.5 billion (Industrial Distribution, 1998).

Residential starts for the period 1996-2001 will probably average about 1.35 to 1.4 million units. Total housing starts are expected to decline slightly on an annualized basis, but the single-family segment will likely approximate the 1996 level in 2001. Multifamily construction will be less, while home improvement and repair work will continue to increase. Home ownership will still be affordable as interest rates are expected to remain low over the next 5 years. The net effect of these trends will be a modest home-building growth through the beginning of the next century.

A great deal of the US infrastructure is structurally deficient. More than half (58%) of US roads are in poor or fair condition (Miles). The 1998 \$200 billion dollar highway and mass transit bill is the largest increase in public works spending in the nation's history. This represents congressional recognition of the need for infrastructure improvements and repairs as well as a movement to make the highway trust fund secure from raids by advocates of other programs.

Enterprising American construction and engineering firms have been successful competitors in the international contracting business. Most of their overseas construction, however, is done by foreign affiliates using local labor rather than by cross-border export of US labor. In 1995, American-based design firms received \$5 billion in international billings, while general contractors won \$20 billion in foreign contracts. Most of the US exports of construction services are engineering and management services and specialized technology.

Local favoritism is one of many concerns for US builders trying to operate in foreign markets. The most successful firms create a presence in the country by sending in a team to open a local office. Either they are licensed or they buy or partner with an existing firm. Even with these competitive tactics to penetrate markets, there are some impenetrable barriers. The worst case of foreign protectionism appears to be Japan. It has been placed on the "Title VII Watchlist" and the "Special 301" list for repeated systemic open market violations. These include barriers to products (wood, glass), to public procurement (government construction contracts) and to construction equipment.

Financing

Financing is an essential element of competitiveness, often making the difference between success and failure in the award of a project. Privatization of the infrastructure, along the lines of build-operate-transfer or its derivatives offers innovative financing possibilities. Project development can use the security of future revenues from

infrastructure operations as collateral to secure predevelopment investment capital. Equity participation and public-private cooperative ventures are other forms of financing innovation. Partnerships, joint ventures, and alliances foster the sharing of risk and allow firms to leverage their investment capacity. International institutions, such as the World Bank, are alternate sources of financing.

The construction bonding market has also undergone significant transformation in the past several years. Bonding insurance has become increasingly flexible in response to changing industry. Surety firms have responded to innovations such as design-build, which requires performance bonds to cover both design and construction (Brady, p. 46). Bundling and wrap-ups have become more prevalent and less costly alternatives for contractors, by reducing costly management overhead (Brady and Charette, pp. 38-39). Niche-specialty bonding firms have also appeared in response to nontraditional forms of construction services. In the face of increasing global competition, the selection of imaginative, flexible and effective financing and surety instruments will be a key strategic imperative.

Project Delivery

Project delivery, or project delivery system, is the broad term used to describe the overall process for furnishing construction of buildings and other structures. This entails the entire design and construction process that includes all contractual actions, financial arrangements, and various forms of agreements leading to the successful completion of a project.

Design-bid-build's share of the overall project delivery base continues to decline. Owners are tending to shift to design-build which shifts the burden of project management to a single entity (especially as the public sector becomes more comfortable with evolving delivery systems). Partnering and alternative dispute resolution will become more prevalent as owners seek to mitigate costly disputes and delays. For 1996, the top 100 design-build firms generated \$39.5 billion in revenue, a 9.7% increase over 1995. This is approximately the same growth experienced over the prior year. However, what is significant is the rate of design-build growth abroad, which has exceeded 20% for the last 2 years. Design-build firms expect continued growth as US firms continue to downsize their engineering, construction, and facilities management departments. As design-build becomes more widely accepted in the public sector, we should see even greater growth. Contract Management (CM)-for-fee had been declining, but has resurged in the last 2 years, creeping over the \$6 billion mark in 1996. However, it is still below the

peak of \$7.5 billion in revenues for the top 100 CM-for-fee firms in 1992.

The Japanese have traditionally used design-build. Their solid R&D programs have benefited the consumer and the construction industry. Design-build is the project delivery system of choice. Japan uses design-build on more than 70% of its nonresidential projects and the European community uses design-build on more than 50% of its nonresidential construction projects. With construction becoming more and more a service industry, the ability to move information becomes increasingly critical. Information technology has fostered more effective and responsive collaboration between American firms and their international partners and affiliates. Information technology will no doubt favor those project delivery systems that are more service oriented, where clients who are looking for quick guidance will seek CM-type providers.

Labor

During World War II, government policy was to promote actively unionism as a means of ensuring labor peace. It was during this period that union membership in the construction industry reached historic peak levels of more than 85%. After the war, the impetus for unionization diminished and subsequent decades saw a gradual decline in the industry's level of union membership. Economy-wide, during 1996 the number of workers represented by unions decreased by nearly 100,000. Among private sector employers in the construction industry, the proportion of unionized workers seems to have leveled at 18.5% (Leonard, p. 10). While many contractors have gone open shop, others operate "double-breasted" (i.e., with two separate concerns, one union and one open). This allows them to bid either way based on the competition, user preference, and market orientation in a given sector or area (Northrup, 1997, p. 3).

Wage comparisons between open-shop and unionized workers are very difficult due to variations in nomenclature, job classifications, and regional markets. Nevertheless, one 1996 open-shop survey, covering 19 craft categories, showed a weighted average hourly rate for wages and fringes of \$15.28 for open-shop journeymen while another showed an average union rate of \$28.39 (Northrup and Alario, 1998, p.10). Based on comparisons like these, estimates of how much the Davis-Bacon Act inflates federal construction costs vary from zero to 15% (Lyons, p. 73).

On the other hand, there are drawbacks to the decline in unionism. Pension and health benefits are unevenly applied in nonunion employment. There also is a marked decline in apprenticeship training,

traditionally an area of responsibility for unions. The situation is contributing to a national shortage of skilled labor.

Unemployment nationally was 4.9% in December 1997, but 8.9% in construction where it has been between 8% and 10% for the past year. The unemployed are lower skilled workers. Unemployment is very low among skilled trade workers. Officials at the Association of General Contractors (AGC) cited a shortage of skilled and unskilled laborers attendant with low unemployment nationally. General labor shortages exist in certain areas of the country while others are experiencing shortages of skilled workers. AGC saw a need for the construction industry to compete for the pool of female and minority labor to keep up with construction demand.

Research and Development (R&D)

Construction has not traditionally been an R&D leader. The average construction firm has fewer than 10 employees, is highly cost competitive, and reputation dependent. Low profit margins leave little incentive and limited funds for R&D investment and experimentation. On average, construction firms invest 0.5% of total revenues on R&D compared to 3.7% for all industries (Civil Engineering Research Foundation).

The importance of government-sponsored research is significant in the highly fragmented construction industry. The research laboratories of our armed forces undertake much of the government-sponsored research applicable to construction. The US Army Corps of Engineers has a preeminent role. Four Corps laboratories and other technology centers provide services to the Army and other governmental agencies on a reimbursable basis.

The National Science and Technology Council's (NTSC) Committee on Technical Innovation, State-Federal Technology Partnership, and Committee on Transportation Research and Development, DOE's National Industrial Competitiveness through Energy, Environment, and Economics (NICE₃) program and the National Institute of Standards and Technology (NIST) Construction Materials initiative are examples of recent construction research and technology development efforts. These R&D efforts focus on high performance construction materials and systems, advanced information systems, process automation, productivity, safety, energy efficiency, reduction in regulation, and waste reduction (NIST).

Many government investments in infrastructures such as roads, bridges, ports, tunnels, airports, and dams spur cooperative R&D

initiatives with significant government funding at the state and federal levels. The majority of these R&D efforts are coordinated through the NTSC. The Civil Engineering Research Foundation (CERF) facilitates, coordinates, and integrates the majority of the construction industry's technology collaborative efforts.

For example, the 1996 NTSC and CERF initiative in construction materials included R&D in composite materials such as high performance concrete, steel, polymer-matrix composites, coating materials and roofing systems as they relate to structural integrity, corrosion protection, and fire safety. Additionally, significant efforts are underway in intelligent transportation systems to improve inter-modal surface transportation efficiencies and safety and to achieve energy efficiency technologies to save energy, to lower costs, and to reduce waste and environmental damage.

Regulations, Codes, and Standards

The American National Standards Institute represents the US at the International Organization for Standardization (ISO), a group of 91 countries developing voluntary, uniform standards across a broad spectrum of industry economic activities. The European Union is working hard for adoption of its standards as the ISO standard. A survey of firms by the Construction Industry Institute's International Standards Task Force found that 92% of respondents felt that there would be a long-term positive impact. Competitiveness would increase because of the US' ability to adapt and implement international standards in the construction market (Yates and Aniftos, p.7).

The industry no longer views change to the metric system as a barrier to US competitiveness in international construction. The American Association of Cost Engineers found that conversion is proving much less difficult than anticipated. There has been no appreciable increase in design or construction costs. The Association concluded that American architects, engineers, and tradespeople adapt readily to working in metric measures on the job site ("Smart Metric," p.1). The International Code Conference is preparing metric versions of its model codes and is working with Canada and Mexico on joint adoption.

CHALLENGES

The major challenges facing the construction industry are skilled labor scarcity, global competition, foreign competition in the US construction market, and privatization.

Skilled Labor Scarcity

Approximately 340,000 skilled construction workers per year will be needed over the next decade to enroll in apprenticeship programs (Fletcher, p. B8). To have enough workers, this sector will need to accommodate women, workers whose first language is not English, and older workers (Thiers, p. 32).

Assuming the construction industry can attract sufficient workers to fill the shortfall, who will provide the training? Although apprentice training in the union sector is well established and funded through collective bargaining agreements, the number of apprentices now being trained reflects the union's decreased market share and is substantially reduced from prior years (Business Roundtable, p. 6).

Although the open-shop sector has established the National Center for Construction Education and Research to standardize training curricula and skill certification on a national basis, the voluntary cents-per-hour contribution method has worked only in a few areas of the country. It has not received broad support from owners because, with few exceptions, they have no confidence in or cannot validate that contractors are actually directing part of their compensation to training (Business Roundtable, p. 6). Although standardized training is a start, it is not a self-fulfilling prophecy. To be successful, it will require consistent, broad, across-the-board support of contractors, owners, and building associations nationwide. Without it, the quality of the open-shop construction will deteriorate until it loses market share, or until the open-shop providers are forced by market forces (or by their legal liability for substandard performance) to provide adequate training to their workers.

Global Competition

In 1992, the global construction market was worth about \$3 trillion a year. Some recently released statistics show a significant growth in the cross-border exports of construction services by US firms. Net construction export receipts doubled to almost \$3 billion from 1991 to

1996. With only \$500 million in imports, the US had a \$2.5 billion trade surplus in this economic sector. The largest importer of American construction services was the Asia-Pacific region (45.6%) which includes the six largest import countries (of which Japan is ranked third). The second largest importer was the Western Hemisphere (25.1%, mostly in Latin America) followed by Europe (14.2%) [MacAuley].

The recent economic difficulties in Asia have "made many construction and engineering firms rethink their previously bullish prospects there and beef up marketing south of the border" (Wright). South America, especially Brazil and Chile, is expected to see a construction boom over the next few years. Despite the temporary slowdown in the Asian market, the need for infrastructure construction remains. A representative of CERF recently stated that 85% of the Asian infrastructure projects, needed by 2015 for economic development, have yet to be built (Belle). The US construction industry needs to be prepared to take advantage of the opportunities in Asia, and in the rest of the world.

In Japan, the governments of Japan and the US signed two initiatives to open up the Japanese construction market. These were the 1991 Major Projects Arrangement which set aside a list of projects for foreign participation and the 1994 US-Japan Public Works Agreement which committed the Japanese government to reform the bidding process (Glain, p. A11). Despite these agreements, significant barriers remain to foreign firms wanting to do business in Japan.

Japan also employs a strategy that gives it an advantage in winning international construction projects. Its key component is central government financing of feasibility studies and projects in the developing world through their Official Development Assistance (ODA) program. The best prospect for US firms to enter an ODA project is to partner with a Japanese firm.

Japanese firms also use an industry structural model called "keiretsu" that improves their competitive advantage. The keiretsu is a group of interfirm alliances. Each member of the keiretsu has a financial stake in the success of the other members. This interdependence facilitates a reduction in costs, risk-sharing, and efficient operations (Putnam and Peng).

In recent years, American firms have moved away from the traditional "go it alone" approach. US industry has been developing an "American keiretsu" type model as a means to improve its global competitiveness.

American firms are also forming strategic alliances with international competitors in order to reduce costs and to help enter new

markets. A good example of this is a 50-50 joint venture between Caterpillar Inc. and Mitsubishi Heavy Industries LTD. This leads to the conclusion that networking between firms, suppliers and customers, and even between competitors can provide the American construction industry a means of reducing cost, increasing innovation, sharing risk and easing entry into new markets.

Other means of increasing international competitiveness of the US construction industry include: government taking a more active role in targeting specific markets (Amin and Hagen, pp. 94-104); firms taking advantage of competitive intelligence (Attaway, pp. 25-35); and firms improving as financial engineers (Khazanent, p. 38).

Foreign Competition in the US Construction Market

While the largest American construction and engineering firms look to the global market to expand, the domestic market appears relatively secure. So far, the lucrative US construction market has seen little penetration by foreign firms. Of the \$580 billion spent in the US construction market in 1996, foreign-based firms contracted for only \$14.5 billion. However, the large-firm, large-project market does have foreign competition. The competition is from a few, very large international firms that compete with a relative few large American firms on very big, complex projects.

Large foreign firms seeking to penetrate the US domestic construction market use many of the same strategies that the US firms are using to compete successfully abroad. They establish strategic alliances with US firms with complementary construction experience and expertise. Their focus is on large projects where the benefit of more efficient management, new building technology, information technology, and financial expertise can create greater efficiencies. Projects with fully integrated improvements in planning, safety and technology can realize greater than 30% cost savings.

The ability of large US construction firms to secure financing, and to design, manage, construct, and operate completed facilities yields a significant competitive advantage in the domestic and global markets. The integration of these tasks while working with multiple individual firms (local and foreign) provides a profit potential that is not possible in construction or engineering. US firms use partnering to overcome local obstacles resulting from regulations and labor forces. They use local expertise and management as much as possible. A great deal of construction expertise and project management skills is being developed within the host country.

With more private and less public construction, the ability to secure financing for the customer is becoming as important as the expertise needed to deliver the project. This explains why large firms are seeking international alliances and financial support on a global scale. Large Japanese and European companies are successfully meeting this challenge in the US market. Just as the global market favors large US firms working through local companies or subsidiaries, large foreign firms that are well financed and technologically competitive vie for the very large and complex projects in the US. They partner with local contractors and focus on project management, financing, and integration of design-build.

Currently the impact of foreign construction and engineering firms on the overall construction industry in the US is small. Consequently the large US companies appear to be more concerned about competing with these foreign firms in the international market rather than the US market. The globalization of the construction industry appears to effect a relatively small segment of the total US market. In summary, the largest and most complex projects are the main target of global competition, where money can be made in the efficiencies possible through integration of all aspects of project delivery from design to financing.

Privatization

Energy, air transportation, and water treatment plants (drinking water treatment and wastewater disposal) are three types of infrastructure that are being privatized. All types have proven profitable for private industry while meeting the public's needs successfully. Prison construction and operations and wastewater treatment plants are being privatized in the US. In the Pacific Rim region, the major regional industries targeted for privatization are energy, drinking water plants, wastewater treatment, and oil field exploration and production. Across the board, these countries are privatizing their energy industry in an attempt to sustain national economic growth. South America is concentrating on privatizing its commercial airports.

Privatization of the infrastructure is occurring worldwide. The political changes of the last decade greatly accelerated this activity. Spurred by the sell-off of European telecommunications companies, privatization could reach the \$100 billion dollar mark for 1997; compared to \$88 billion in 1996. It appears that governments worldwide will continue privatizing at record rates for the near-term future.

OUTLOOK

The study group's assessment of the construction industry's health is that it is extremely robust. Domestically, the US has an enormous competitive advantage. Although the US does not dominate abroad, we are competing ever more vigorously for foreign market share. American practices in construction management, quality assurance, and safety are being exported as the industry expands into foreign markets. Positive macroeconomic factors—and particularly government fiscal flexibility—favor growth in private, commercial and government construction. Innovation in project delivery and financing are providing leverage of existing resources to maximize investment.

The real question is how to keep the industry healthy and insure its strength in the future. American business success depends upon forming successful strategic partnerships between complementary US and foreign firms that are able to present a project owner with solid financial, design and build packages. Forming partnerships with foreign firms can ease the entry into foreign markets, and help mitigate the cultural differences that are often a source of friction in international business transactions. The international construction market can provide great opportunities for American firms that are able to adapt.

Future Health of the Industry

The long-term health of the industry is largely dependent on the state of the nation's economy. Growth in the industry, while perhaps not as spectacular as the past few years, will be steady. We can anticipate modest growth in the residential and commercial building segments, especially if interest rates remain low. There is considerable business and consumer confidence in the state of the economy. It is in the area of infrastructure spending that we will see expanded demand because of the need to renew the existing infrastructure and to keep apace with the growth in the economy. Privatization and public-private joint ventures will provide financial leverage to spur this demand.

Information technology will continue to enhance efficiency and effectiveness in the design and construction management phases of construction. Innovations in project delivery, financing, and materials remain the three greatest potential areas for competitive advantage.

National Security Implications

The state of the nation's infrastructure is critical to the capacity of the nation to exercise its national power to its full potential. During an international visit, the study group was struck by the "Asian Tiger" nations' commitment to infrastructure development — in the midst of economic crisis — as the key to their future economic growth and national well being. There is a growing political consensus that America needs to make a considerable reinvestment in US infrastructure to ensure long-term competitiveness. Recent trends in our nation's construction industry have obvious implications to national security.

- Current strategic doctrine demands a US infrastructure capable of supporting force projection and an industrial base equally capable of building, maintaining, and expanding that infrastructure nationally and internationally in potential theaters of operation.

- Government is committed to revitalizing our national infrastructure. However, there does not seem to be any overarching assessment of national security priorities for the infrastructure development.

- American firms are gaining invaluable experience in international construction projects and in the operation and maintenance of infrastructures, often under austere conditions in potential areas of conflict. This has positive implications for mobilization planning.

- The consolidation of American construction firms may adversely affect the level of competition in the domestic market and our international competitiveness.

- The national shortage of skilled construction labor is of great concern: it could constrain industry growth, increase the cost of construction, limit the pace of infrastructure renewal, and create shortfalls in mobilization surge requirements.

- Privatization is changing the nature and scope of military construction capabilities. The degree of downsizing in force structure and the need to reduce costs is driving the impetus for this. Privatization of military capability must be done with an appreciation of the time needed to reconstitute a military capability. Therefore, privatization decisions should be made in a deliberate and conscious manner with a long-term view. Military planning must now include the new private-sector players so that the on-site commander can adequately evaluate their capabilities and limitations.

- The maintenance and operation of infrastructure is no longer strictly a government function. Military planners must be prepared to

deal with private-sector firms, including their structure, organizational culture, and methods of operation.

GOVERNMENT GOALS AND ROLE

The government can exercise considerable influence on the construction industry, as a regulator, consumer, investor, advocate and partner. Its fiscal, monetary and trade policies foster political, economic, and social conditions that determine the current and future health of the industry. Government initiatives such as privatization and environmental remediation, and policies ranging from education to research and development will help shape the nature and direction of the industry. The role of government is thus twofold: to create a favorable environment for the industry and to promote actively the industry as a means of furthering national interests and objectives.

International Assistance

A key tenet of our national security strategy is to promote free market economies as a means of fostering regional stability and democratization. The development of a modern infrastructure is fundamental to a nation's future economic prosperity and a cornerstone in any program of international assistance. Our government has a significant role to play here, both in its support of World Bank activities and in its own direct aid programs.

Open Access to Markets

There has been a gradual opening of foreign markets, but there is considerable room for improvement. Regional and national protectionism still inhibits American industry from expansion abroad. Continued government support for World Trade Organization efforts to reduce trade barriers is necessary but not sufficient. Bilateral negotiations are crucial to gaining unfettered access to foreign markets, particularly when seen in the context of overall trade balances. For nations where a significant American trade deficit is a source of friction, improved construction industry access may alleviate the problem.

At the same time, we must be aware that market access is a double-edged sword. Our domestic market faces little foreign competition at present—but this will change. Government must balance a natural tendency to protect American industry with a need to be consistent in its international trade policy of favoring open markets. Consumers, industry,

and investors will benefit in an arena of more open competition, at home and abroad.

Labor and Education

The shortage of skilled labor is worrisome. There are no quick or easy fixes for the contributing factors of relatively low wage rates, a declining demographic pool of future workers, and inadequate institutional vocational education.

We need a revitalization of vocational training. Although this calls for a partnership among government, business, unions, and the education industry, it would appear that the initiative for leadership and coordination rests with government by default. To draw partners, the industry needs funding and incentives.

Immigration offers another solution, providing policies are sufficiently focused on skills, education and potential. Another means would be to relax labor policies for the entry of construction workers for specific projects or programs.

Research and Development

One of the greatest contributions the federal government can make is to bring leadership to an industry that lacks an R&D strategy. In addition to direct sponsorship, government can look at partnership ventures with industry and the use of incentives and preferential contracting for firms willing to make the investment in R&D. Promotion of new construction technologies such as energy efficiency improvements will also spur industry and consumer interest in innovation.

The government must do a better job of supporting the promulgation of new technologies throughout the industry. For instance, the Corps applies many of its Corps-developed technologies to its civil and military construction projects, though many of these technologies have broader-based applications. The Corps has an active technology transfer program that is directed at commercial use of new techniques, processes and products.

The military engineering labs already are exploring many of the construction and engineering trends of the next century: automated construction processes and equipment, sustainable development, "green" design and construction, modular construction, advanced building and control systems, national and international standards codes, and performance-based design (Belle).

Industry Standards

The government has a clear responsibility for the regulation of industry through the promulgation of codes and standards for quality and safety. However, the proliferation of regulation and jurisdiction has created an environment that frustrates industry efficiency and effectiveness. Today an important goal for governments at all levels is to rationalize and coordinate standards and codes for the ease of both industry and the consumer. There is a lot of work being done in the residential building sector, but there is a long way to go. The gradual adoption of international standards by the industry will help—conversely; government can support the export of American standards in safety, quality and environmental considerations.

Investment in Infrastructure

There is widespread a political consensus at all levels of government that America's infrastructure badly needs recapitalization to repair, modernize, and expand its capacity. This is not a new finding—this has been accurately assessed for the past two decades. What has changed is the recently improved fiscal performance of governments, coupled with the strong performance of the economy. This has provided governments with budgetary freedom of action, and they have taken legislative action to invest in our infrastructure. We have a window of opportunity that we cannot afford to squander.

Privatization

This offers government an opportunity to divest itself of infrastructure development, operation, and maintenance, areas where the private sector is both willing and able to go. This allows the government to focus its efforts and resources on those infrastructure requirements where business either cannot or should not be involved. Programs such as the Logistics Civil Augmentation Program also permit civilian contractors to perform construction services in wartime and other operational contingencies. This policy has become part of DoD's military logistics strategy and generates savings in military force structure.

CONCLUSION

The US construction industry remains critical to the economic might of the nation and the well being of its citizens. The industry is thriving and adapting to changing conditions at home and abroad. Concerns about the state of our national infrastructure appear to have galvanized government action. It demonstrates a general recognition of the importance of the infrastructure to the national well being. The projected increase in transportation infrastructure spending over the next decade will spur industry growth. Other areas of our nation's infrastructure like water supplies, dams, and utilities, require similar investment. If government cannot provide all of the needed capital, then perhaps privatization and other forms of project delivery and financing can make up the difference.

US firms can compete successfully abroad. They must continue to use local talent, to use technology to harness talent elsewhere, to partner with local companies, and to provide financing. The requirement for large infrastructure projects is growing; US firms with a reputation for world-class design and management will be in demand.

The US domestic market will continue to be characterized by numerous small firms and a few very large, globally competitive firms in a fiercely competitive market. Recruiting and training of a skilled workforce is a problem area that requires more attention. The US educational system remains weak in preparing students for trades. The industry training base lacks uniform standards, and is fragmented and poorly funded.

The government can continue to play a strong role in promoting and sustaining a healthy construction industry that is competitive domestically and globally. Ultimately, its strength is essential to our long-term economic prosperity and national security.

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EDUCATION

ABSTRACT

Education is important to the US because it develops our most valuable resource, our people. It provides our youth the basic knowledge necessary to function productively in our society; it bridges the learning environment and the work place; it prepares working adults to transition from one work experience to another; and it is the foundation of our democratic form of government. As we approach the 21st century, the ability of our current system of education to adequately perform those roles has been questioned. Our schools must shed the outmoded methods they have used for more than 150 years to respond to emerging technological advances, changes in the American economy, and increasing global interdependence. Although myriad solutions to the perceived ills of America's education systems have been proposed and attempted, none have proven universally satisfactory.

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PLACES VISITED

Domestic

AFL/CIO, Washington, DC
American Association of School Administrators, Arlington, VA
American Federation of Teachers, Washington, DC
Boston Renaissance Charter School, Boston, MA
Chelsea Public Schools, Chelsea, MA
District of Columbia Public Schools, Washington, DC
Fairfax County Public Schools, Fairfax, VA
Federal Aviation Administration, Washington, DC
Fidelity Investments, Boston, MA
Focus: HOPE, Detroit, MI
Francis W. Parker Charter School, Ft. Devens, MA
General Motors Corporation, Pontiac, MI
Harvard University, Cambridge, MA
Head Start Program, Washington, DC
Jefferson High School for Science and Technology, Alexandria, VA
Maryland State Department of Education, Baltimore, MD
Minuteman Science-Technology High School, Lexington, MA
Motorola University East, Mansfield, MA
National Governors' Association, Washington, DC
Northern Essex Community College, Haverhill, MA
Organization Economic Cooperation and Development, Washington, DC
Potomac Job Corps Center, Washington, DC
School to Work Opportunities, Washington, DC
The Boston Private Industry Council, Inc., Boston, MA
The World Bank, Washington, DC
US Department of Education, Washington, DC

International

Action 2000, London, England
Department for Education and Employment, London, England
Enfield School, Enfield, England
Central London Training and Education Council, London, England
London School of Economics, London, England
Qualifications and Curriculum Authority, London, England
Chamber of Commerce and Industry, Baden-Württemberg, Germany
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INTRODUCTION

The US has prospered for over two centuries as the result of a fortunate combination of abundant land, labor, and capital; relative geographic isolation; and fundamentally sound political and economic systems. Still above all else, the spirit, minds, and efforts of the American populace have made our nation the preeminent global economic and political power it is today. Our people are our strength. Accordingly, the means by which we train our work force and educate succeeding generations of young Americans for the future deserve close and constant examination, analysis, and adjustment when necessary. Nothing is more fundamental to our continued security and prosperity—and the full, productive life of each citizen—than our collective efforts to ensure appropriate, quality education and training are provided to all Americans. The purpose of this study and the aim of this report are to define the current state of the education industry, to identify potential national security implications of the study group's findings, and to determine the extent to which American education and training programs fulfill the needs of those they serve.

The study group's analysis was comprehensive and specific. The group gained a broad perspective of the industry through interactions with diverse education and training professionals, government representatives, students, trainees, and members of the work force and management. The study group acquired detailed insight into specific education and training issues through individual research on topics of interest.

Each successive exposure to a new aspect of the industry provided greater understanding of the complex interrelationships and forces that influence education and training in the US. As the study progressed and gained momentum, the study group began to see recurrent patterns—some gratifying, some disconcerting. It became increasingly clear that the ability of our education industry to sustain American competitiveness is questionable. All interested parties agree that a basic function of our education and training programs is to provide the human and social capital necessary to ensure the future prosperity and security of our country. Although deficiencies in the education industry may not constitute an immediate threat to national security, the cumulative effect will weaken the nation's economy and burden the country through increased social support costs. While there is general national consensus that "something needs to be done" to improve the system, there is no consensus on what that "something" should be.

THE EDUCATION INDUSTRY DEFINED

For some, accepting the study group's definition of the education industry may first require a successful defense of the notion that such an industry exists at all. Quantifiable figures such as profit margin, market share, etc. normally associated with businesses have little direct applicability to the generally accepted concept of education. However, there clearly are "customers" of US education and training (society, businesses, communities, etc.). Further, there are products of the various component schools and training programs (graduated students and trained workers, for example); and there are measures of relative system effectiveness that can be determined or approximated (such as standardized test scores, graduation rates, and success of graduates). Additionally, there are investments, expenses, management/labor issues, and government regulations and oversight that in some degree characterize most US industries.

If a US education industry does exist, how may its condition, response to customer needs, or "profitability" best be examined and ascertained? The study group confined its study to those components of education and training that fit into one of three general categories: schools (prekindergarten through secondary), transitional institutions (which provide the bridge from school to the workplace), and the workplace itself. In that context, a broad analysis of US education and training as a single industry facilitated a rigorous examination of its current state, significant trends, and ways to ensure its future viability. In this paper, the terms "education" and "education industry" refer to education and training conducted in all component areas.

Schools

The schools component of the education industry includes 111,486 primary and secondary schools, in 14,772 school districts nationwide. Given the vast differences across America in demographics, population density and community norms, and the US tradition of local control of schools, it is not surprising that expectations, outcomes and funding levels vary widely with location. For the 1996-97 school year, the Department of Education estimates that total outlays for public schools exceeded \$313.5 billion. Based on figures for school year 1994-95, the federal government contributed 6.8% of total expenditures, state governments an average of 46.8 %, and local communities the remaining 46.4 %. The estimated per-pupil expenditure of \$6,564 in 1996-97 represented an increase of 13.6 % (in constant dollars) over that of a

decade ago. An additional \$26.2 billion was spent in 1996-97 on private elementary and secondary school education (National Center for Education Statistics, 1998a).

Also included in this component are those initiatives tailored to intervene in at-risk cases. These include programs like Project Head Start, where approximately 715,000 children ages three to five from disadvantaged backgrounds are provided comprehensive education, socioemotional development, physical and mental health assessments and intervention, and nutritional services (Administration on Children, Youth, and Families).

In all, over 52.2 million students, 3.1 million teachers, and 2.7 million other professionals, administrators, and support staff participate in the schools component of the education industry (National Center for Education Statistics, 1998a).

Transitional Institutions

The transitional institutions component includes those programs and facilities charged with the development of specific skills, knowledge, or work-related experience to support the anticipated career needs of individual participants. The most diverse of the three education industry components, it ranges from universities to vocational schools, from community colleges to apprenticeship programs, and from government-funded training to business supported partnerships. In all, an estimated \$350 billion is spent on transitional programs annually.

The Workplace

Business investment in formal employee training is estimated at \$60 billion annually (Voytek). This includes worker skill training, broad professional development, and remediation of the performance shortfalls of the other two components of the education industry. The approach taken by individual firms regarding workplace training varies considerably. However, the degree to which the current tight labor market affects those firms and their dependence on technology generally dictates their level of investment and corporate philosophy regarding this element of the education industry.

The Seamless Whole

The education industry as defined above is unique, in that the individuals it serves may be considered its "products" and a segment of

its "customers." Further, every member of American society is affected, to some degree, by the ability of the education industry to function properly at each level. Therefore, the state of the industry and the manner in which the three components support each other and those they serve deserve further examination.

CURRENT CONDITION

"The schools aren't as good as they used to be and never were."

Will Rogers

Opinions regarding the current condition of the US education industry are as varied as the perspectives from which they are developed. The human and social capital outputs of education programs cannot be quantified. Thus, those interested in assessing the effectiveness of the industry must rely on a combination of indicators—none of which are direct or completely reliable performance measurements, and all of which are subject to interpretation.

For example, taking a broad view, current low unemployment rates, growth in gross domestic product, robust international competitiveness of US businesses, and declines in violent crime may be interpreted to indicate that there is nothing amiss. One could conclude that the general prosperity of our nation is improving, and that the elements contributing to that prosperity must be adequate. However, a disinterested observer may come to a different conclusion if he or she considers our domestic adult illiteracy rate of 21% (National Center for Education Statistics 1998a), declining standardized test scores, and growing wage disparity within the American population. Overlay that observation with the fact that education in the purest sense is a subjective, individual experience, and the task of objective assessment becomes even more difficult.

The group geared its study toward developing conclusions regarding the ability of the US education industry to support our national security interests. Thus, a significant portion of the group's assessment of the education industry's current condition is based on what the group determined were the most objective and globally oriented standards available. Though the group's aim is to provide an overall assessment, the breadth of the industry requires that we first examine its component parts.

Schools

Within our schools, an aging teacher pool serves our growing student population. While teacher attrition is holding steady at about 7% per year, 36% of teachers nationwide are now teaching core subjects in which they neither majored nor minored. Instead, they studied education, focusing on pedagogical methods, the history and philosophy of education, and child development (Finn). Once they acquire a position, teachers are often less engaged in teaching than in attempting to maintain order in their classrooms. While teacher unions advocate various methods of broad schoolhouse reform, they continue to demand teacher pay scales based on numbers of advanced degrees and seniority, with little regard for teacher performance or subject matter expertise. Large classes, led by frustrated, ill-prepared teachers are the norm, rather than the exception, within many American school districts.

What does this environment produce? Surprisingly, based on the performance of US fourth grade students on the 1997 Third International Mathematics and Science Study (TIMSS), our primary schools appear to be meeting the challenge. The US ranked highly (third in science and eleventh in math) among the 26 countries participating in the fourth grade portion of the study, a position consistent with previous international standardized results (National Center for Education Statistics, 1998b). The international assessments of US elementary school students' reading ability also support the conclusion that our elementary schools are in good shape. Despite these encouraging results, however, a significant number of young students, particularly those in many urban and rural schools, fail to master the fundamentals of literacy and numeracy necessary for success in higher grades. With their education derailed early in the process, many eventually elect to leave school before graduation. This may be a root cause of the current annual US high school dropout rate of five percent (National Center for Education Statistics, 1997a).

Despite their relatively strong start, by the eighth grade US students' math and science knowledge is below the international average, according to the TIMSS. By the twelfth grade they ranked fourth from the bottom of the 21 participating nations (National Center for Education Statistics, 1998b). In a 1997 Organization for Economic Cooperation and Development international survey of literacy, the US population scored in the middle for prose literacy and in the bottom half for document and quantitative literacy (Organization for Economic Cooperation and Development). These results indicate that our secondary schools are failing in their mission to equip America's youth

with the skills necessary to ensure future US competitiveness in a global economy.

Although a recently announced federal initiative encourages all children to aim for a college education, currently only 60% of high school graduates enter college and only 46% of those earn a baccalaureate degree within five years (National Center for Education Statistics, 1998a). Young adults who don't continue their schooling often seek unskilled jobs in business and industry—jobs that, in the past, usually led to a comfortable middle class lifestyle.

However, the nature of American industry has changed. Major manufacturers, such as General Motors, have instituted rigorous methods for screening applicants, even for unskilled jobs. They assess the basic skills of reading and quantitative literacy, and soft skills such as teamwork, critical thinking, and problem solving abilities. This skill set is now required of workers at all levels in modern manufacturing facilities. Many applicants fail to achieve General Motor's minimum standard of ninth grade level for reading and tenth grade level for math. Of those who do pass, many are deficient in the soft skills—not a surprising outcome. The typical American school curriculum or teaching methodology does not emphasize these skills.

The traditional teaching approach taken in most American primary and secondary schools may produce graduates comparable in quality to those of 20 to 30 years ago, but the good jobs available today require a new set of basic skills. Some schools are responding to the changes in the workplace and have implemented innovative programs to prepare students for transition to work and to postsecondary education. Schools that continue to teach a more traditional comprehensive program typically produce a small number of graduates fully prepared to do well in college. A greater percentage of their students either drop out or graduate with mediocre skills, having put forth the minimum effort necessary to get through.

Transitional Institutions

The postsecondary education system in the US is still the envy of the rest of the world. The best and the brightest of our own students, as well as those from many other countries, receive a top-notch education at the undergraduate and graduate levels. Most of our public and private colleges and universities produce well-prepared graduates who have little trouble finding employment—often supplanting high school graduates who lack the basic skills to do the job. Postsecondary education in the US is widely accessible, even for those whose high school performance

was below average. As previously mentioned, many students, particularly those who may have chosen to attend college due to parental or societal pressure, do not graduate.

Our community college system is widespread and performs a critical role in preparing students for today's workplace or for further education. However, the literature suggests and the group's visit to a community college confirms that many students require remediation in the essential math and literacy skills they failed to master in secondary school. Many community colleges have formed relationships with local business and industry, and are more responsive in meeting specific local industry and community needs than are local public high schools.

The Workplace

Business and industry realize that a well-trained workforce is essential to future competitiveness. Some industries, particularly those requiring technically skilled workers, are experiencing difficulty in finding enough qualified candidates. Their response to this need has been varied, ranging from in-house training programs and partnerships with local high schools and community colleges to moving work offshore or generating political pressure to relax immigration requirements for technically competent foreign workers. Among the most effective programs that address this shortfall are business intern programs and partnerships with schools. Many companies have become "learning organizations" where education and training for all employees are woven into the corporate fabric, producing a highly capable, motivated, and loyal workforce. Other firms fill their skilled employee requirements by hiring qualified workers away from business rivals. Thus, competition between firms produces excellent training opportunities for employees who seek to keep their skills current.

Overall, the US education industry is meeting the needs of those it serves—but just barely and in an inconsistent manner—because the Transitional Institution and Workplace components of the industry have adapted to obviate the weaknesses of our secondary schools. The schools attended by today's youth are strikingly similar to those their grandparents attended more than half a century ago. Those "factory model" institutions were designed to produce a fairly homogeneous mass of workers with the basic literacy and numeracy skills necessary to function in a labor-intensive work environment. Many of today's high school graduates, who in years past would have constituted the bulk of the middle class, are now destined to become the working poor of the future. This system, while marginally effective in meeting business and

industry requirements, is inefficient, leaving in its wake far too many people unprepared to compete for good jobs.

If the increasing obsolescence of US public schools continues, "the children of the wealthy and clever will be clustered in privileged schools—public and private—that do emphasize appropriate skills. These children will get good education and the good jobs, and the vast majority of other children will compete for what is left." (Murnane and Levy, pp. 6-7). Perhaps most disturbing is that, while most Americans believe schools are doing a poor job, the majority of parents give their own children's schools high ratings. They see their children studying as much and mastering essentially the same material they covered in school—not realizing that the skills necessary to earn a good living in 1970 are not good enough today (Murnane and Levy).

CHALLENGES

At the core of any debate over the quality of our education industry is the product of its secondary school system. In America, high school graduation connotes a passage from one stage of life to another—a line of demarcation where the burden of education is intended to shift from the shoulders of society to those of the individual. For better or worse, each new high school graduating class represents the total of 12 or more years in a system that exists for the sole purpose of preparing its participants for a productive future. Those former students are the product of the schools component of our education industry, and the eventual input for the remaining two. In essence, the factors that contribute to the degree to which those graduates are poorly prepared for their future define the major challenges faced by the entire education industry.

While not endemic to every classroom, the factors described below characterize the challenges faced by many American secondary schools. These are the challenges that must be addressed if the US education industry is to effectively promote our national security in the future.

The current secondary school system in the US was designed according to a factory model and produces graduates suited for industrial age jobs—jobs that are decreasing both in number and in relevance to our continued global competitiveness. In this postindustrial age, even unskilled jobs require new basic skills that our traditional comprehensive schools do not teach. Except those who pursue a rigorous academic track in preparation for college, students in most high schools learn little of immediate practical use in performing today's jobs. Just as businesses and corporations are adjusting to compete in a rapidly evolving

marketplace, schools must be reengineered to prepare workers for changed jobs in those same businesses and corporations.

Therefore, the greatest challenge facing the educational system today, at least at the secondary level, is to provide a thorough and adequate education to every student no matter the path they choose to take following high school graduation. With this end in mind, four fundamental questions must be answered. What should be taught? How should it be taught? How should we evaluate whether it is being learned? How should we accommodate, within the same system, students going in different directions following high school?

Arriving at satisfactory answers to these questions is a significant challenge, but the following is a summary of the opinions of a number of current education reform advocates.

What should be taught? The new basic skills required of all graduates include traditional core competencies such as mathematics, science, and English, with the addition of computer literacy and problem solving. It includes soft skills such as the ability to work in groups, to think critically, and to make effective oral and written presentations. Also, in order for the education system to promote social cohesion, concepts like civic responsibility and societal values must be conveyed. Beyond these basic requirements, students should be taught in greater depth those skills required for their chosen post-high school paths. Students bound for college should study appropriately rigorous academic material while those who intend to enter the workplace directly or pursue additional technical training should take courses and participate in practical work experience with direct relevance to today's workplace.

How should it be taught? All course material should be taught at a depth sufficient to ensure student understanding to the point where the knowledge gained can be applied. Most of the curriculum that is taught in high schools today is superficial, designed to cram as many facts as possible about a particular subject, with little regard for practical application. Textbooks are bloated and teachers are pressured to cover as much material as time allows during a term. The Scholastic Assessment Test (SAT), American College Test (ACT) and other national and state standardized evaluation tools are primarily content-based, multiple choice tests, reinforcing this teaching approach.

A cooperative learning methodology, where students interact frequently with each other and with their teachers, has been far more effective in promoting understanding of subject material and in developing the soft skills described above. Instruction founded in real-life experiences and examples, utilizing case studies, projects, and practical application, and hands-on training in the laboratory or work

environment, produces graduates better prepared for productive employment or postsecondary education.

How should we evaluate whether it is being learned? As noted above, traditional means of assessment are usually content based. While knowledge is important, the ability to apply that knowledge is even more so. Only performance-based assessment can adequately evaluate that ability. One effective assessment approach is the use of student portfolios containing samples of the student's best work. In addition, students may be required to defend their mastery of through written and oral presentations. Students' understanding of the material is thus assured, and valuable presentation skills are also developed. Finally, teacher observation of student performance in individual and group efforts is essential. This requires that teachers have a limited number of pupils they instruct during a term so they can know each student well enough to make an informed evaluation.

How should we accommodate, within the same system, students going in different directions following high school? Traditional high schools offer varying degrees of choice to students, often dependent upon the size of the school and the resources available. Unfortunately, except for college bound students, those choices may include little that is relevant to the postsecondary school plans of most graduates. Considering the answers to the three questions posed above, each student should be required to complete a common core curriculum more rigorous than is typical today. With a solid foundation in place, students should pursue combinations of advanced academic studies; courses that require practical utilization of academic knowledge; hands-on application in the laboratory; and supervised work experience appropriate to their chosen future career objectives.

While agreement on the answers to these questions is hardly universal, there are a small, but sufficient number of successful programs in existing schools to prove the effectiveness of these new approaches to learning. Why then are they not more prevalent? The answer, the study group believes, lies in the significant challenges faced by the current system in reforming itself. These challenges are related to the curriculum, teaching methodology, teacher skills, resources, resistance to change, and assessment and evaluation.

Curriculum

The current curriculum used in most American high schools is content based, extremely broad, and shallow. This contrasts with the Japanese system in which students are taught fewer topics, but to a much

greater depth of understanding. While more appropriate curricula are being developed by some school districts, this is not a widespread trend within the US.

Teaching Methodology

The traditional expository teaching method applied in a format of multiple, independent class periods per day with a duration of one hour or less per period does not support effective learning. Combined with our grade-level-by-age school structure, this methodology reflects the factory model on which it is based—students become mere products of the assembly line, moved to the next stage in the process regardless of subject matter mastery. Teachers at the secondary level frequently have contact with 150 different students (or more) during each term, severely limiting their ability to get to know the needs of individual students (Sizer, 1998). The different learning styles of individual students are infrequently accommodated, as all students are expected to conform to the same pedagogical method.

Teacher Skills

Many teachers lack sufficient competence in the subjects they teach, especially in the mathematics and science disciplines. They cannot teach subjects to any depth that they do not completely understand themselves. Also, few teachers who are products of traditional college teacher training programs have been taught how to teach effectively in a cooperative learning environment.

Resources

Many debates have taken place over the question of whether money (above some basic level) matters in education. All agree that adequate resources are necessary, but funds provided to most American schools are not sufficient to guarantee quality programs consistently. The US spends less on public education (as a percentage of gross domestic product and as a percentage of per capita income) than many developed nations (OECD). Although more money is not, by itself, a solution, increased funding can make a significant difference if properly used with other reform initiatives. The successful programs that the group visited invariably required funding significantly above the current per capita average for other schools in the same district. Generally, those programs

obtained their additional resources through grants or other financial support from business and industry.

Resistance to Change

Our bureaucratic education system is similar to many large, highly structured organizations that resist changes that threaten vested interests, familiar methods, or accepted convention. Teacher unions, for example, although supportive of change in many areas, have resisted reforms regarding teacher performance-based remuneration and the introduction of competition within school districts for students and program funding (fearing the possible effect on teacher jobs). Yet, without significant competition in the public kindergarten through twelfth grade sector, individual schools have little incentive to improve. While experience has shown that meaningful change does not usually take place until parents demand it (Murnane and Levy), most parents are satisfied with the performance of their children's schools. One common factor the group noted in virtually every successful reform effort was that hard work is required of everyone involved—administrators, teachers, parents, and students. The unwillingness of one or more of these groups to either recognize the fact that change is necessary or to fully participate in the process will destine those efforts to failure.

Assessment and Evaluation

The lack of easily obtained accurate measures of education effectiveness makes it difficult to judge the impact of reform initiatives. An overwhelming amount of data is available on past test scores, but it is primarily from content-based examinations that do little to predict success in the workplace or even in follow-on education. For example, performance on the SAT (a principal admission decision tool of many colleges and universities) correlates directly to parental income, but only slightly to first-year college performance, and not at all to college grade point averages or graduation rates. Data is also available on graduation rates and employment of graduates and nongraduates, but the results of this data appear to depend far more on the state of the economy than the effectiveness of education. One possible source of meaningful data is the percentage of high school graduates found qualified for employment in various businesses and industries and the remediation and additional training required to make them productive. However, this information, where it exists, is often considered proprietary by the companies that compile it, and is not available for analysis. Until a performance-based

national assessment method with widespread acceptance is established, evaluation and comparison of alternative education reforms will remain challenging.

OUTLOOK

There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things.
Machiavelli

While the challenges faced by the American education industry today may be unique to our time, the fact that our education processes are under fire is not. Calls for school reform and improved methods of worker training became an American tradition well before our nation was formally established. In our recent history, significant technological breakthroughs by rival nations and periods of extended recession intensified the feeling that somehow the education industry was failing. It needs immediate, bold action to close some perceived knowledge gap and to remain secure and prosperous as a nation. In retrospect, past attempts to apply education reform to challenges stemming from unrelated fiscal policies, the dynamics of market swings, or the serendipitous good fortune of competitors were illogical. It is also true for blindly ascribing our nation's current good fortune to education reform.

To date, we have managed to educate adequately and to train our population sufficiently to maintain our global competitiveness. However, that outcome resulted from the fundamental soundness of our systems of government and commerce and from the large numbers of low skilled, well-paying jobs available to American workers in the past. The American education industry was able to keep pace with the gradual shift in education and training requirements as we moved from the agricultural age to the industrial age. The change in demand was moderate enough to accommodate a system of education inherently slow to adapt appropriately. Now, at this dawn of the information age, American industry has rapidly accelerating requirements for new basic and advanced skills. We risk our preeminence in global competition and the quality of life of our individual citizens if we fail to address adequately the shortfalls that currently exist in our education industry.

If the first step toward a solution to those shortfalls is recognition that there is a problem, the US is on the right path. There is no shortage of pundits, experts, and concerned citizens proclaiming their version of our education ills, and many of their opinions are reflected in the

preceding pages of this report. The group's assessment of the nation's likely response and possible outcomes follows.

Short-Term Outlook

During the next five years, the inefficient manner in which the schools component of the education industry prepares young Americans for their future will remain an overarching concern. Although many education reform initiatives are under consideration or in place, their near-term effects will be minimal. Businesses, postsecondary education institutions, and taxpayers will continue to bear the burden of remediation or social support (just as they do today) for those leaving secondary school unprepared for their future. However the expanding direct and indirect costs of that burden on transitional institutions and in the workplace will increase the demand for reform and innovation.

Within the schools component, one example of how that demand is manifested is the current debate over whether introducing competition, through vouchers, charter schools, or magnet schools, might improve existing public primary and secondary institutions. Many believe the free market dynamics created by such a move would offer parents and students a better range of educational choices and would motivate traditional schools to improve.

Though competition is promising in concept, the equitable distribution of resources is a concern. For example, opponents of school voucher programs believe that such a diversion of funds from public to private schools would increase the total cost of education without any appreciable overall benefit. Since vouchers would not cover the total cost of private education, students without the financial means to pay the difference between tuition and the amount of their vouchers would be left behind in schools in even worse financial shape than before.

Of far greater promise to the future of American students are pilot programs created within some districts—magnet schools, charter schools, and the like—tailored to meet specific community or local industry needs and the career directions of their students. Generally characterized by highly motivated staffs and student bodies, partnerships with local businesses and academic institutions, and a penchant for innovation, these schools focus on preparing students for their chosen postsecondary school endeavors. The study group visited three such US schools (two academic and one geared toward technical training). These schools were strikingly similar to the German Gymnasium vs. apprenticeship track system that the group observed.

In the German education system, a degree of pragmatism is injected early in a student's scholastic career. For instance, at the completion of primary school (based on their academic aptitude and preferences), children begin tracking toward either postsecondary school education or direct entry into the workplace. Those destined for universities (about 25%) attend an academic high school, or Gymnasium. The others participate in government-sponsored, industry-funded, apprenticeship programs beginning at about age 15. Apprenticeship training lasts from two to three-and-a-half years; those who complete the program earn a qualification certificate and are fully prepared for immediate entry into the labor force as skilled workers (Gesellschaft).

It is doubtful that Americans would ever universally accept such a system in the US because they cherish the notion of a university education. Unlike the Germans (or the English, who have developed a similar system), most Americans value the options of the "one size fits all" academic track. Ironically, approximately the same percentages of German and American high school students eventually receive a college degree. However, for those students, parents, and communities willing to make the commitment; magnet schools, charter schools, and other secondary institutions with well-defined missions and clarity of purpose can deliver impressive results. Though these pilot programs will have minimal impact on the near-term health of the education industry as a whole, their potential long-term benefit is significant.

A direct consequence of our current tight labor market (and an ironic benefit of our secondary school shortfalls) has been a surge in investment in workplace training by industry and in innovative transitional programs within many communities. From corporate boardrooms to inner-city neighborhoods, the group witnessed many amazing successful human capital development initiatives, each tailored to meet specific firm, local industry, or community requirements. These trends, coupled with the remediation centers established with the welfare-to-work requirements enacted by many states, bode well for our future competitiveness if the momentum can be maintained.

Long-Term Outlook

The study group is cautiously optimistic that the current turbulence within the education industry will eventually generate the broad changes necessary to sustain the global competitiveness of our nation and to ensure the quality of life of our citizens. This optimism is based on the group's witnessing first-hand the truly inspirational efforts of many dedicated educators and government officials; the determined attitudes of

business leaders, corporate training professionals and concerned citizens; and the infectious, unabashed enthusiasm of students and trainees of all ages who had found their educational niche. The group's caution stems from the certain knowledge that these individuals are the exception rather than the rule, and that without a strong national effort and focus they will remain so.

Implications for National Security

Many Americans still recall the stir created by the launch of Sputnik 40 years ago and the demand for swift, radical education reform that ensued. Still, was the perceived national security threat really the result of a failed education system? The system was then and is now well suited to preparing those exceptional Americans who lead the world in breakthrough discoveries; it is unlikely that lack of education reform will endanger our technological edge in the foreseeable future. The group believes that the national security implications of a failing education system are subtler, yet more profound. As previously noted, jobs available to unskilled Americans are declining, as are the wages paid for those that are available. Yet, our schools are generally not teaching the skills necessary for moderate to well-paying employment, leading to the phenomena often called the "shrinking middle class." As the wage disparity grows between the well educated and the underskilled, so too grows the probability that an increasing percentage of Americans will become disaffected. The potential costs—in terms of social support programs and national cohesion—are significant, as are the implications for our ability to sustain our global competitiveness and to adequately resource our national defense requirements.

GOVERNMENT GOALS AND ROLE

The group's study of the education industry has led to two inescapable conclusions. First, there are no "magic bullets," no simple solutions to the problems we face. Though the symptoms of these problems may appear similar across the nation, they generally require remedies unique to the particular level and circumstances in which they occur. Second, meaningful improvement requires hard work and motivation by all involved. This motivation cannot be engendered by top-down directives or even by increased funding (to which restrictions or conditions are invariably attached). The stimulus for positive change begins with acknowledgment that a problem exists, a clear understanding of its nature and possible corrective measures, and ready access to the

means to do something significant about it. The goal of government—at all levels—must be to become a catalyst for change and to provide the information and fiscal resources necessary to make improvement possible.

Clearly, a centrally directed and controlled public education system, such as exists to a greater or lesser extent in the countries the group visited, runs counter to American culture and ideals. Even if such a system could be implemented here, it would have little chance of success. Government can and must play an important role in producing and sustaining quality education systems, but that role is most effective when government serves as an informer, facilitator, and financier. Comparisons between centrally controlled and free market economies readily demonstrate that quality and efficiency are produced by freedom of choice for the consumer and competition between producers, not by government control. The same holds true in our education processes. Accordingly, the following policy recommendations regarding government's proper role in the future of our education industry are provided.

Government as Informer. Most parents believe the US education system is doing a poor job overall, although they are generally satisfied with their children's schools. The group believes this apparent contradiction stems from an absence of meaningful criteria by which to judge school and student performance. The only criterion available to most parents is their child's report card. Passing grades are accepted as evidence of sufficient learning.

Evaluation of the effectiveness of a school is based on the aggregate performance of its student body on standardized tests. These tests, which measure relative content knowledge among students, have questionable value in predicting future success in school or the workplace. The best indicator of a school's performance is found in the answers to the following questions. Where are the students who recently graduated? If the school is an elementary school, are its former students taking algebra in middle school? Do middle school graduates end up in advanced classes in high school, or are they in remedial classes, or dropping out? Do high school graduates go on to further education or good jobs, or do they end up in dead-end jobs or unemployed? Colleges, universities, and most private schools, which operate in a competitive environment, frequently advertise the success of their graduates as evidence of the quality of their programs.

National, state, and local government agencies, because of their oversight responsibilities, are in a good position to develop and implement processes that provide parents and students with information

about school performance. Schools should be evaluated based on subsequent achievements of all students leaving the school, not just those who excel. Statements such as "seventy-five percent of our students go on to college" reveal nothing of the fate of the other 25%, nor whether those who attend college earn degrees. Comparisons of test scores are useful only if the tests are performance-based and objectively evaluated according to meaningful standards.

While the value of national standards is hotly debated, there is clearly value in identifying the knowledge and skills needed for success in the modern workplace or in pursuit of higher education. Many professional and craft organizations have developed certification programs for workers in their fields. Colleges and universities have identified factors (apart from SAT or ACT scores) that indicate which of their applicants have the best chance of success, and they use those factors in their admissions processes. Similar information could be used by government to compile performance-based standards and assessments for primary and secondary schools for use in evaluating their students and programs.

Finally, government can also be a valuable source of information on successful programs implemented by schools and school systems. There are many exemplary school reform efforts currently in place in a variety of environments and conditions. A few of these efforts have been documented, but the results are disseminated haphazardly through occasional books or articles in education journals. The successful initiatives that are publicized result in many requests for information and visits, distracting both the staff and students from their teaching and learning routines. If government, starting at the national level, implemented programs to identify successful programs, documented the results, and disseminated the information widely, reform efforts by other schools and systems could be greatly accelerated and much "trial and error" eliminated.

Government as Facilitator. Change is difficult enough without facing the barriers frequently erected by government bureaucracies. The concept of charter schools has been implemented in many areas in an attempt to overcome this impediment. Government can and must do far more in this area to remove the barriers to progress while insuring that all students are afforded the opportunity to obtain a quality education. Government must become a facilitator of change rather than a hindrance.

Introducing choice and competition in the education system is perhaps the best way to foster improvement. The high quality of the postsecondary system in the US is largely due to the presence of these factors. Recognizing that no one school or program is best for every

student, some secondary schools attempt to provide enough variety to meet everyone's needs, losing their sense of purpose and mission in the process. If schools were encouraged to specialize, and parents and students were allowed to choose schools suited to their interests, all would benefit. Voucher programs, charter schools, magnet schools, and specialized high schools are approaches frequently used to introduce choice and competition. Government should support such efforts where equal access and opportunity are preserved. Indeed, government's primary oversight role in this area should be to ensure, through legislation and court action, if necessary, that equity of opportunity is provided to all students.

The federal government, in particular, is in a position to distribute effectively educational resources for use throughout the country. For example, the widespread availability of cable television and the Internet provides new methods for schools and individuals to access education resources. Properly applied direct and indirect government support for educational programming and distribution will make these resources the modern equivalent of the public library.

Through fiscal policies, government can encourage participation in education by individuals, firms, and industries. The federal government has recently implemented tax changes that provide incentives for individuals to seek further education in order to update their skills. Business and industry should also be offered financial incentives to provide greater support to public education. Based on historical results that show a high correlation between education level and future earnings, government can expect to recoup this investment through future income-tax revenue and the avoidance of social support program costs.

In facilitating education, government must resist the urge to declare that one path is best for all students. While many parents would like their children to go to college, there are many skilled jobs available that require merely a solid high school education and some specific skill training. The efforts of the government would be more productively directed toward insuring that all high school graduates possess the basic skills and training necessary to succeed in whatever path they choose.

Government as Financier. In any public education system, one of government's most important roles is as financier. Sufficient funding for education is a necessary, but not sufficient, condition for success. Funding must be applied appropriately to achieve maximum benefit and the government has a responsibility to demand accountability of schools and systems that receive it. This does not require government to control how the money is spent, but rather to evaluate the results of the investment. Public school funding is, and will remain, primarily a local

responsibility. The state government must insure that resources are distributed to provide a balance between well-to-do and poorer regions and school districts. In this role, the government also has a responsibility to acquaint those without children in school regarding the societal benefits of sufficient funding for education, while insuring that society receives the promised benefits through the effective use of tax revenues.

CONCLUSION

The seeds of change generally go unnoticed when sown. Similarly, the first steps in a sequence of events that eventually lead to dramatic reform are often not recognized. For example, through a series of seemingly unrelated decisions, US mobilization for World War II set the stage for the unparalleled prosperity of the 1950s and 1960s, as the benefits of our investment in the GI Bill were realized. In the same manner, *Brown v. Board of Education* forever altered our concept of universal public education and the right (still regrettably ephemeral for many to this day) of all Americans to equality in education. Yet, to ascribe those outcomes to mere happenstance would do a great disservice to those who had the vision and fortitude to pursue a bold course of action despite the factors that argued against success.

Similar visionaries exist within our education industry today. The group is certain that practical solutions to the conditions outlined above are possible. In some instances, they are already in place (although on a small scale). As a nation, as communities, and as individuals, forgoing the status quo and fostering a climate conducive to continued educational innovation and reform is our greatest challenge. The need for change is clear and the means for change is achievable. We need to have the collective fortitude to examine and debate the issues. We need to implement those measures best suited to meet the needs of our citizens, to maintain our global economic competitiveness, and to ensure the future security of our nation.

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ELECTRONICS

ABSTRACT

The electronics industry is multifaceted – from children's game software to elements of major weapons systems. It includes many of the most innovative and profitable companies in the US, but embodies some of the biggest problems facing the nation—a paucity of trained technical workers; issues of market control; problems associated with rapid obsolescence, particularly of military components; and concerns about international alliances and national power. The computer and semiconductor sectors are among the most robust in the world, generating billions in profits and ushering hundreds of millions of people into the 21st century. Computers are becoming ubiquitous; soon it will be practically impossible to tell where the computer ends and the home appliance, entertainment unit, medical apparatus or communications device begins. The software sector continues to feature innovation and excitement unknown in most industries. It is impossible to imagine any realm of life that the electronics industry is not changing profoundly.

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PLACES VISITED

Domestic

Allied Signal, Towson, MD
Center for Innovative Technology, Herndon, VA
Dominion Semiconductor, Manassas, VA
Gensym, Chantilly, VA
Lockheed Martin, Bethesda, MD
Northrop Grumman, Baltimore, MD
Oracle, Bethesda, MD
Raytheon, Lexington, MA
Siemens Medical Systems, Cary, NC
ST Research Corporation, Newington, VA
TRW, Fairfax, VA
Virginia Semiconductor, Fredericksburg, VA

International

EL-OP, Tel Aviv, Israel
ELTA, Tel Aviv, Israel
Formula Software Group, Tel Aviv, Israel
Motorola, Tel Aviv, Israel
RADA Electronics, Tel Aviv, Israel
ASELSAN, Ankara, Turkey
Center for International Strategic Studies, Marmara University,
Istanbul, Turkey
DEIK (Foreign Economic Relations Board), Istanbul, Turkey
Microwave Electronic Systems Inc. (MIKES), Ankara, Turkey
Office of Defense Cooperation, Ankara, Turkey
Siemens, Istanbul, Turkey
Sikorsky, Ankara, Turkey
Turkish-American Business Association and American Chamber of
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INTRODUCTION

One of the most phenomenal aspects of the electronics industry is its advanced pace, opening technological horizons considered absurdly optimistic just a few years ago and rendering yesterday's dreams already obsolete. Also impressive is its spectacular economic growth. National security has not escaped this revolution; there is an increasing reliance on electronics to field the most modern and capable combat force in military history.

In addition to the widely acclaimed benefits, the exponential growth and ubiquity of electronics brings formidable challenges. The pervasiveness of integrated circuits increases vulnerability to cyberterrorism from domestic and foreign sources. The Year 2000 software problem has the potential to do unimaginable damage to the world economy. Yet, the electronics industry remains one of the most vibrant sectors of the economy; its products continue to find innovative and productive applications in every field.

US electronics production exceeds \$600 billion in sales. The US is the world's largest electronics market and the largest exporter. Electronics exports have increased roughly 50% since 1990 and make up about one-third of all factory sales.

This report provides an overview of the complex electronics industry, its contribution to the economy and national security, and its major challenges, opportunities and vulnerabilities. It is based on extensive literature studies, presentations by industry leaders and senior government officials, and visits to leading companies in the domestic and international electronics sectors.

THE ELECTRONICS INDUSTRY DEFINED

The electronics industry is overwhelming in its breadth. Few generalizations are possible about an industry that extends from digital televisions to complex weapons systems. To assess the industry better, it will be considered in five sectors: semiconductors, computers, software, consumer electronics, and defense electronics. Each has uniquely identifiable subsectors and its own market sensitivities, supply/demand outlook, and challenges. Most sectors are characterized by high capital costs, short product cycles, rapid technological change, significant employee shortages, and intense competition. As the Nation's largest basic industry and principal industrial employer, the electronics industry is a major driving force behind the country's economic prosperity.

Computers

Structure. Globally, the computer industry's market structure is monopolistic competition. Growth in computer hardware sales is driven mainly by business needs for data management and accounting automation. Introduction of the personal computer (PC) and powerful desktop applications moved computers into the home and, more recently, to networks that allow systems integration.

The US leads in production and sales in every computer market: PCs and notebooks, large systems, PC servers, and workstations. Compaq Computer has been the PC leader for several years, with 14% of the world market in the third quarter of 1997. The next four producers, which account for about 25% of the world market, are Dell Computer, IBM, Hewlett-Packard Co. (HP), and Packard Bell-NEC.

Large multiuser systems, including supercomputers, mainframes, minicomputers, and servers, account for 35% of the \$85 billion annual worldwide computer market. The Unix server market, led by HP and followed closely by Sun Microsystems and IBM, had estimated 1997 revenues of about \$23 billion.

IBM accounted for 73% of \$11 billion in US mainframe sales in 1997. The PC server market is expanding rapidly due to increasingly powerful desktop computers; some 1.7 million units were shipped in 1997. The top five distributors, led by Compaq, control 66% of the market; other major producers are IBM, HP, Digital and Dell.

Unix-based and PC-based workstations account for some 5-7%, or about \$18 billion, of the world computer hardware market. Unix vendors once accounted for 85-90% of the market, but more powerful and cheaper PCs workstations have forced a market shift. In 1997, PC workstation consumption surpassed Unix by 431,000 units.

Semiconductors

Growth in semiconductors has been even more spectacular. Despite rapid demand growth, prices have declined steadily. According to Intel's Andrew Grove, "The United States now enjoys what in many respects is the healthiest economy in its history, and probably that of any nation ever. . . Driving all this is the microchip." Global competition to produce the fastest, most efficient chip is spurring industry development.

Internationally traded semiconductor products include integrated circuits, discrete devices, and parts (including semiconductor wafers). The high-tech industry buys almost 80% of all semiconductors. High-end, high-value consumer products are the fastest growing sector. PCs

are the largest end user, but chips drive everything from simple watches to complex equipment mapping the human genome, as well as home entertainment systems and automotive parts such as antilock brakes, airbags and electronic ignition systems.

Semiconductor production is capital intensive. Research and development (R&D) and fabrication costs exceed those of any other industry. In 1996, US manufacturers invested \$9.5 billion in new plants and equipment. Firms spend more than 12% of their revenues on R&D. Despite significant costs of R&D and production, technological advances and torrid global competition continue to drive down the cost of microprocessing capacity; prices have declined about 30% per year since 1970.

Structure. In just 8 years, the industry's growth has propelled microchips from 17th to the nation's largest manufacturing industry, measured by sales. From low-end, simple commodity semiconductors to high-end application-specific chips, the microchip fuels the American economy. In 1996, the American chip industry added \$41.6 billion to US sales. Since the 1991 recession, employment in the semiconductor industry has grown 4.3% per year, 8.6 times faster than all other manufacturing employment. In 1996, the industry employed 257,000 people at an average salary of \$54,900—nearly twice that paid to workers in other industries. Since 1996, the demand for semiconductors has created 1.5 million additional direct and indirect jobs and provided wages totaling \$49.6 billion for US workers. The industry grew 15.7% annually between 1987 and 1996 (more than three times faster than the overall economy). It is a significant factor in the growth of America's gross national product.

The industry is shifting from a vertically integrated, monolithic, single nation-based business to a horizontally integrated industry thriving on multinational partnerships and alliances. Global sales grew by 4% in 1997 to \$137.2 billion.

Although there are some 200 US semiconductor firms, the US semiconductor industry is an oligopoly dominated by a few major players. Three US companies are in the top four worldwide. Intel was first in 1997 with sales of \$21 billion—a 19% increase over 1996. Motorola moved from fifth to third with \$8 billion in sales; Texas Instruments moved from seventh to fourth with \$7.6 billion. NEC, a Japanese firm, was second with \$10.6 billion in semiconductor sales. US firms continued to dominate the industry in 1997 with \$45.3 billion in sales and a 33% share of the global market.

Software

The US software industry, with nearly 75% of the world market, is experiencing exciting developments and trends. Increasingly, computer, communications, and cable technologies are merging. Software leads the convergence, fueled by the popularity of the Internet, deregulation, and cheap computers. Increasing industry partnerships, alliances, and mergers reduce risk and quickly add needed capability.

Structure. The software industry is dynamic. Though dominated by large firms, a multitude of small companies develops and markets applications software. In 1997 alone, some 191 start-up software companies entered the market—double the number in 1990. The industry includes giants, like Microsoft and IBM, each with 1997 sales exceeding \$13 billion. Other notable firms include Novell, Corel, Oracle, Informix, Sybase, Computer Associates International, PeopleSoft, EDS, Broderbund, and Computer Sciences Corporation. The largest foreign company in the software industry is the German SAP AG, the fourth largest software maker in the world, with sales of \$4 billion.

Software industry mergers are common and are expected to continue. Firms can be “faster to market” or obtain start-up technology through acquisition. Large firms have the cash flow, marketing muscle, and access to key distribution channels that small firms lack.

Industry structure varies from small one- or two-programmer shops to firms that employ thousands. Barriers to entry are low in some market segments, such as those related to the Internet. On the other hand, Microsoft enjoys a near monopoly in PC operating systems and suites (integrated packages typically containing word processing, spreadsheet, and presentation graphics applications).

Consumer Electronics

Structure. The consumer electronics (CE) sector includes home information products, telephones, televisions, radios, cameras, VCRs, CDs, DVDs (digital versatile disc), and home satellite dishes. Dominant US manufacturers include Motorola, NEC America, IBM, and JVC Disc America. Prominent retailers are Best Buy (\$8.4 billion in sales in 1997) and Circuit City (\$8 billion). Most other retailers had sales under \$1 billion.

Overseas suppliers (Sony, Sanyo, Panasonic, and subsidiaries of Motorola and General Electric) dominate production. Japanese firms continue to dominate the global market with an estimated production growth of 3.5% in 1998 to a record 27.1 trillion yen (\$197.5 million).

The US imported \$20.1 billion of CE products and exported just \$4.4 billion in 1997.

During 1996, CE manufacturing in the US contributed \$9 billion in wages to the US economy and accounted for 170,000 jobs. The retail sector provided 5.6 million US jobs.

CE markets are saturated with many brands and discount pricing. Some discounters promote a single brand, as Wal-Mart does with Sanyo, K-Mart with General Electric, and Target with Sony. Overall, 60% of upscale retailers named Sony their top performer. Sony continues to be the favorite brand among consumers for the fifth straight year.

CE has very low margins principally because of vigorous foreign competition, often based on cheap labor, and the initial high cost of technological breakthroughs. US policy is to encourage innovation and challenge countries that fail to protect intellectual property rights of US companies. For example, the US levied 100% tariffs on imports of Chinese products in 1995, including \$108 million on answering machines and cellular phones. Many nations with large CE industries have lower wage structures than do competing countries.

CE needs skilled technicians for service and repair; the scarcity of labor is an endemic problem, begging for leadership from trade associations. Availability of skilled labor has become a critical issue to industry when considering new plant investments.

Defense Electronics

Electronics equipment is integral to nearly everything the military uses, from aerospace components to undersea systems. The sector includes stand-alone electronics and communication equipment; subsystems embedded in aircraft and guided missiles; and systems installed in ships, tanks, satellites, and other combat equipment. Applications include electronic warfare, avionics, reconnaissance, air defense, and surveillance systems.

Structure. The defense industry is more concentrated than at any time in a half-century. The end of the cold war prompted a dramatic reduction in defense spending, generating substantial excess capacity. In response, the industry consolidated. In 1997 defense electronics industry mergers and acquisitions totaled \$33 billion, yielding a handful of financially powerful, vertically integrated "one-stop-shopping" mega-corporations.

Advances in weapons system complexity and sophistication have driven up costs—further limiting production as defense procurement

volumes decline and, in turn, reducing demand for capacity. The defense electronics sector is operating at no more than 45% of capacity.

Defense electronics firms have difficulty meeting the pace of rapid technological change that requires enormous capital investments and frequent industry refits. Large defense electronic systems contractors can survive only if their annual revenues exceed \$1 billion. Coupled with declining US military spending, this has made the industry more reliant on foreign sales; for some, such revenues account for nearly 40% of sales. However, the global market is shrinking and becoming more competitive.

CURRENT CONDITION

Computers

US shipments of PCs and peripherals surged 21% – to 31 million units in 1997, or 36% of world shipments and totaled \$260 billion, up \$10 billion from the 1996 level. Sub-\$1,000 PCs pushed US home computer penetration to 43% in 1997, up from a record 35% in the fall of 1996. Worldwide PC shipments in 1997 increased 15.8% to 82 million units.

Servers, the fastest growing segment of the industry, are expected to represent 35% of worldwide revenue growth for PC sales. Servers are gaining popularity over large proprietary systems like mainframes because of their more flexible architecture. Use of client/server networks in which low-cost computers distribute applications to hundreds of desktop clients is increasing.

In just 4 years, the Internet, the global computer network, has metamorphosed into more than 70 million interconnected computers. In 1997, a new computer was added to the Internet every four seconds, doubling the network every 10 months. With more than 58 million US adults online in third quarter 1997, up from 37 million at the end of 1996, the Internet is in an exceptional growth phase. Internet expansion has focused attention on security, as users attempt to protect themselves from fraud and theft. The Internet has spawned corporate Intranets using Internet infrastructure and standards within enclosed company networks.

Software

The trend in software is for more features and enhanced interoperability. Software prices have declined; some companies give away software to gain market share. Profitability varies widely in the

industry, from Microsoft, which earned a 27.7% profit in 1997, one of the highest in the world, to Informix and Novell, that lost money.

The Internet is a key change agent spreading the information age throughout the globe. Although conceived in the US, the Internet is a global phenomenon with worldwide implications and issues. The volume of information on the Internet and its well-known sub-component, the Worldwide Web, continues to grow at an incredible rate. Java programming language is changing the industry. Java's unique strength is platform independence that allows it to be used on any operating system without rewriting the software. Java and Java applets have facilitated advertising and minimized costs for Web users.

The Internet has fostered massive growth of electronic mail (e-mail). E-mail will not eliminate regular (or "snail") mail, but already is changing the method and frequency of communication. Governments and industry have embraced the Web to assist customers and transact business. Search engines that assist users in finding information have become popular. The Internet also is expanding distance learning capabilities; eventually it may change our educational system.

Online buying, or electronic commerce, grew rapidly in 1997 to \$1 billion in the fourth quarter, doubling from a year earlier. Business-to-business electronic commerce totaled \$9.5 billion in 1997; by 2000 the market may reach \$26 billion and the revenue potential for the consumer sector in electronic commerce will approach \$15.5 billion. Electronic commerce brings with it concerns about data security and taxation, but it is expected to alter retailing radically over the next several years. Stores such as Egghead Software are closing their doors and operating exclusively online. Amazon.com, the Internet bookstore, represents the new breed of retailer selling exclusively on the Web. Low overhead and high volume provide significant advantages although, to date, profits have been elusive.

Semiconductors

Semiconductor manufacturers are forming alliances to share the high cost of production (a new fabrication plant costs \$1 to \$2 billion), promote productivity, and increase market share. The move to specialization and the search for cheap labor encourage such joint ventures. The trend toward alliances and joint ventures is expected to continue because technological complements among allied firms can reduce production costs. To date, most alliances have been between Japan and US firms – Toshiba/IBM, Hitachi/Texas Instruments, and Fujitsu/Advanced Micro Devices. However, increasingly, European and

Asian firms are forming alliances. National boundaries are fading as firms capitalize on shared risks, production economies, technical expertise, and marketing and distribution networks.

Large companies dominate the semiconductor market; the cost of a fabrication plant represents a significant barrier to entry, particularly for small companies that may lack sufficient capital. Demands for faster, more powerful, cheaper products drive industry development. Innovative technologies have created new products; consumers have responded by quickly discarding older products for updated models and product life cycles have shrunk. In 1997, Intel, the world's largest semiconductor producer, recorded a profit of \$6.9 billion on \$25.7 billion in sales, for a whopping profit/sales ratio of 27.7%.

Despite significant costs of R&D and production, technological advances continue to drive down the cost of microprocessing capacity. For the US, and increasingly for Japan, currency fluctuations, labor costs, and trade barriers make it profitable to utilize offshore facilities, principally for the finishing stages of production.

The Asian financial crisis has caused Asian firms to lose sales, delay capital spending, and slow production; because international markets are linked, Asia's problems have slowed US semiconductor sales. Intel's Asian revenues fell to 3% below the year-earlier figure in the fourth quarter 1997. However, the Asian turmoil is not expected to have a lasting effect on US markets.

Consumer Electronics

Consumer electronics (CE) factory sales in the US, including imported components and exports, reached an estimated \$72.7 billion in 1997. This was an increase of 6% over 1996. Sales in 1998 are expected to rise 5.6% to \$76.8 billion. Home information products (PCs, fax machines, telephones and answering devices) comprised 41% of the total 1997 sales and are expected to dominate CE sales in 1998. More than 1.6 billion different CE devices are in use in the US.

Generally, the US consumer electronics industry has experienced low profit margins, with most manufacturing done overseas as US firms close or convert to more profitable sectors. A notable exception is Thomson, a French-owned company with a large US workforce manufacturing DVD products.

The popularity of DVD technology is impressive. First-year sales of digital video players to US dealers exceeded 437,000 units in 1997 – more than twice the number of videocassette recorders sold during the first 2 years they were introduced and more than 12 times the number of

CD players sold when they appeared on the market. Consumers' familiarity with digital technology in PCs and videocassette players no doubt contributes to soaring sales.

Digital is the new wave in photography. More than two million digital cameras were purchased in 1997, surpassing sales of conventional 35-mm single-lens reflex cameras for the second straight year. Numerous personal and business publishing applications, the expansion of the Worldwide Web, and proliferation of photo-realistic printers contributed to the surging demand for digital cameras.

Convergence products merging traditional audio, video and personal communications products with a PC in products like RCA/Compaq TV-PC and WebTV receivers are poised to dominate the CE market. Emerson Radio's recent turnaround may reflect the impact of the convergence trend. Emerson cut costs and shifted to these high-margin products and, as a result, turned a profit of \$493,000 for the last quarter of 1997, compared with an annual loss of \$5.64 million a year earlier.

Defense Electronics

While military spending has fallen sharply, the percent of the defense budget allocated to electronics has grown due to ever increasing electronic content. Today, at \$51.5 billion, it accounts for more than half of the defense procurement budget. Still, the military share of the overall US electronics market has steadily declined; DoD has become just another buyer. Military electronics sales fell from 25% in 1990 to less than 10% of the US electronics market in 1997.

Key competitors in the military electronics market include Raytheon, Lockheed Martin, Northrop Grumman, Litton, ITT, and Harris. In addition, numerous lower-tier suppliers compete in niche markets for low volume critical components.

Firms have increasing difficulty providing military components in the small quantities required by DoD. Instead, they direct R&D to the more lucrative and rapidly expanding commercial sector. Integrated chip suppliers such as Motorola, AMD, and LSI Logic have abandoned the military market due to low demand and cumbersome procurement policies, thereby reducing source options. Similarly, Intel dropped its military specification products in response to the trend toward commercial-off-the-shelf (COTS) purchases.

DoD and the threat of war once drove microcircuit technology development; today, commercial products do. To leverage the commercial sector lead, DoD is pursuing a COTS procurement strategy that enables the agency to exploit new technology and benefit from the

huge capital investments made by the commercial industry. However, COTS is forcing DoD to recognize and manage new risks.

CHALLENGES

Computers

Computer firms must satisfy rapidly expanding demand for their products. Stocks quickly become obsolescent because technology shifts so rapidly. The keys to success in this environment are careful planning, solid forecasting, and keen knowledge of pricing trends for components. PC life cycles are perilously short—at times, 2 years or less; misjudging market shifts can require price slashing to unload excess inventory. Short life cycles raise the stakes for industry vendors and put a premium on new product introductions; 50% of a company's profits are earned within three to six months of new product introduction. Intense price competition will continue as the computer industry strives for ever-greater market penetration.

Semiconductors

The biggest challenge to the US semiconductor industry is the future workforce; the Semiconductor Industry Association predicts a shortage of some 40,000 workers by 2002. Education must be a priority. Already, many companies are assisting schools and nonprofit organizations with grants, mentoring, scholarships, and volunteer activities. The situation calls for more—only an intense effort by government will satisfy the need.

Software

Challenges to the software industry are daunting. Year 2000 (Y2K) poses a formidable challenge. Firms that trade with Europe also must deal with conversion to the Euro currency. Trained personnel are in very short supply. Issues of monopoly control, encryption, security, privacy, Internet taxation, and intellectual property rights have significant implications for government, the information technology industry, and consumers.

The Y2K problem involves computer programs that express dates in two digits ('98' for 1998) and may read the year '00' as 1900 rather than 2000. This may cause computers – and the equipment they operate – to shutdown or malfunction. Billions of lines of code in older computer

systems must be examined. More than \$100 billion may be required to fix the problem and finance related litigation. Significant resources (programmers, dollars, and management focus) are being diverted to the problem and away from new products and projects. On the positive side, the Y2K problem is forcing companies in many industries to review their legacy systems, reduce redundancies, and reengineer systems.

Conversion to the Euro currency creates a strain for global organizations. Of the 15 nations in the European Union, only 11 meet monetary standards to convert to the Euro so, at least initially, some governments may deal in national currencies while businesses convert to the Euro. Dual and changing standards, coupled with fluctuating exchange rates, will strain an already-burdened software workforce. However, the Euro conversion also opens doors for new intelligent software to aid in the task.

The industry workforce of 2.5 million needs to grow at 7-10% annually to relieve a current employee shortage of almost 200,000 and provide workers for the future. A new generation of employees with technical knowledge and an innovative spirit is needed to keep America strong and competitive. This problem requires broad, long-term, sustained solutions including partnerships between industry and educational institutions; tax credits and substantial tax deductions for college tuition; publicity to increase awareness of the opportunities. Other solutions include raising the cap on foreign technology worker (H-1B) visas and the expanded use of community colleges as high-tech training centers.

Of significant interest to the software industry, the Justice Department is suing Microsoft for monopolistic control of the Internet browser software market and other alleged violations. This may become a prolonged effort not unlike the government's case against IBM in the 1970's or the breakup of the Bell Telephone System in 1984.

Consumer Electronics

The biggest challenge for the CE industry is that most of its current products will disappear, creating a continuing demand for new technologies and products. Further, the CE industry is among the first to feel the effects of recession. Strong economic growth is critical to CE sales.

Lack of DVD content during the next few years is the biggest potential obstacle to the rise of DVD technology. As with VCRs and CD players before them, sales of DVD players and products must pace one another. Future commitments by software publishers may determine the

initial success of DVD. However, sales growth will be impeded if the industry fails to agree on critical elements such as standards for an operating system, display screens, and connection protocols.

CE manufacturers must compete in the low-price – less than \$300 – hand-held product market. This will require an innovative domestic infrastructure to develop products and market them rapidly—critical success factors in the market for hand-held CE products. It also will require manufacturing and packaging technologies that can deliver high-demand products with minimal cost.

Defense Electronics

The defense electronics sector faces equipment obsolescence and restrictive regulations. While COTS procurements have yielded substantial savings, the federal acquisition process requires additional reform. Companies will not commit resources to technologies that are nearly obsolete by the time they are deployed. Consequently, it is difficult for the military to benefit from commercial technology investments. Many firms shy away from military sales, whereas government acquisition policies hamper firms that deal with DoD.

Increased mergers and acquisitions are a dual-edge sword. On one hand, vertical integration increases efficiency. Lower overhead, scale economies, and consolidation of factories can yield more cost-effective products and services. However, May 1997 Defense Science Board findings highlighted potential problems of consolidations unless DoD devises ways to maintain competition in defense acquisition. Reduced competition may restrict innovation and allow costs to drift upward. As a result, the government is closely examining mergers in the defense industry. The Justice Department is delaying approval of the proposed Lockheed Martin/Northrop Grumman merger, concerned over possible reductions in competition and innovation. The Department previously has required divestitures to remedy potential problems.

OUTLOOK

Computers

Some 90.6 million computers will be sold in 1998 compared to about 80 million in 1997. US market expansion is projected to slow from 1997's torrid 19% to 15.4%. Sales growth in Western Europe and Asia will continue to expand in 1998, although at a lower pace than the

previous year. Latin American demand, however, is expected to increase by 18%.

Windows 98, Windows NT 5.0, and the need to support enhanced memory, processing speed and storage could increase computer sales further. Voice recognition software applications will require more memory, greater CPU speeds and larger storage capacity. Developments like these and the ability to make money on the Web could bring 60-80% of the US population into the computer community.

Compaq Computer's plan to acquire Digital Equipment Corp for \$9 billion would be the largest merger in the industry's history. The combined company could have annual revenues of \$37 billion. Nonetheless, the sector will remain highly competitive and vibrant. Indeed, vigorous competition has driven prices down consistently.

Semiconductors

US semiconductor global market share and revenues continue to rise. Europe showed 1997 sales growth of 10.5%, the Americas were up 7.3%, and the Asian-Pacific market increased 7%. Only Japan's sales fell – down 12.8%. The worldwide semiconductor market is expected to grow 8.4% – to \$148.7 billion – in 1998. Annual worldwide sales for 2002 are predicted to reach \$272.4 billion.

The Semiconductor Industry Association foresees dynamic random access memory (DRAM) processes moving from 0.25-micron half pitch line densities in 1997 to 0.18-microns in 1999. Microprocessor (MPU) gate lengths will go from 0.20 microns to 0.14 microns by 1999. By 2012, 256 gigabit DRAMs will have 0.05-micron half-pitch spacing. At the same time leading edge MPUs with 1.4 billion transistors on a chip will be fabricated with 0.035-micron gate lengths. Optical lithography will carry the chip industry to the 0.13-micron generation in 2003 and non-optical technologies could enable 0.10-micron in 2006.

Healthy growth for the semiconductor industry is predicted. While the depreciation of European and Asian currencies has slowed the US industry's growth, it should resume in the third and fourth quarter as demand for electronics products picks up. New technologies, applications, and products will open new markets. By 2010, integrated circuits will represent 77.6% of semiconductor trade; Asia is predicted to be the fastest-growing semiconductor supplier and consumer.

Software

Software is a strong growth industry. Global sales of packaged software are expected to grow 12.8% to \$133 billion in 1998 on the heels of a 12% growth rate in 1997. Impressive as this is, financial outlays for software services (training, consulting, and integration) are often greater. Continued software industry growth is the result of global competition forcing cost-cutting measures, privatization, outsourcing, deregulation, and technological innovation.

Speech recognition or natural language processing software is beginning to show real promise. For 15 years, speech recognition was employed in niche markets such as the medical or legal professions. It was expensive and of limited quality. Recent breakthroughs by IBM and others have increased accuracy while prices have dropped to the \$75 to \$130 range. Speech recognition software is expected in many commercial products, not just the traditional office and home PC markets. *Business Week* calls it "the next big thing in computing."

Enterprise software, which allows information to be entered once and shared across multiple functional areas (order taking, manufacturing, accounting, etc), is changing the way companies organize and conduct operations. It is eroding database software sales.

Business and government generate enormous volumes of data, but finding useful information is expensive and time-consuming. Data mining software identifies relationships in the data and can improve efficiency and effectiveness in this developing field.

"Push" software (user-defined information-grabbing filters) has strong potential. Software packages such as PointCast and Oil Change automatically update information and users' computer software with limited user input. In software, too, the pace of technical change has been nothing less than phenomenal.

Consumer Electronics

A robust economy and a steady rise in housing starts drive demand for CE products and assure continued growth. Consumers tend to equip their new homes with state-of-the-art CE products. Domestic trends such as telecommuting, the popularity of the Internet, and the sale of sub-\$1,000 PCs provide strong stimuli for robust CE sales. Overseas there remain many opportunities for sales of mature US technology products.

Factory sales of CE products are expected to grow at a steady pace. Sales growth is estimated at 6.5% (1999), 6.8% (2000) and 7.0% (2001). Factory sales in 2001 are estimated at \$86 billion, an 18.3% increase

over 1997 sales. The emergence of digital technologies likely will contribute most to that growth at the same time that profit margins for traditional products – television, VCRs and stereo components – have dropped dramatically.

The trend toward digital convergence represents a significant milestone. Home entertainment and home information technologies are merging into a new product category where the same products can be used interchangeably by both PCs and home entertainment devices.

The DVD, with enormous storage capacity and superior sound and picture, will enhance demand for video, audio, telecommunications and computer products. Sales of related products, such as larger, higher-resolution computer monitors, more powerful computer processors, high definition digital televisions and digital cameras are expected to increase significantly once DVD technology takes hold.

Defense Electronics

With the continuing demand for electronic technologies and upgrades, most DoD procurements will be in the defense electronics sector. As a result, electronics firms will continue to be attractive acquisition targets for US defense companies. While vertical integration could disfavor small electronics suppliers, major defense electronics producers are expected to grow significantly over the next 10 years. The overall defense electronics budget is projected to expand nearly 15% by 2007, but R&D is expected to decrease in the short-term. As government cuts R&D spending and focuses on COTS products, innovation could suffer, but commercial potential may offset this tendency and stimulate continued developments.

Upgrades to existing weapons will require more than \$20 billion in modifications, retrofits and maintenance. Components of such upgrades may have commercial as well as defense applications. Bigger budgets for information warfare and DoD efforts to commercialize procurement may create opportunities for new firms to enter the defense electronics market.

As the traditional defense industrial base declines, DoD is turning increasingly to the commercial sector. Further, to penetrate overseas markets, there will be more teaming and joint ventures with foreign firms. However, archaic and cumbersome export licensing procedures penalize US companies that seek to sell innovative technologies on the world market. Such procedures limit US competitiveness in overseas markets, allowing foreign firms to gain important footholds and market shares. They limit US productivity, thereby increasing costs.

Greater use of commercially developed electronics in military equipment creates new civilian profit-making areas such as satellites, telecommunication, and computer simulations. Selling the same products to defense and commercial customers enables larger production quantities, lower unit costs, and significant research, development, testing, and evaluation (RDT&E), inventory, and production-line savings. This strategy positions industry to respond to the federally mandated use of COTS procurement and stimulates cost-savings and quality-improvements in an expanding electronics sector positioned to deliver. Consequently, there will be fewer pure defense firms.

GOVERNMENT GOALS AND ROLE

National Security Implications

Our nation's security is linked to the unlimited potential of the electronics industry. America's Armed Forces, the economy, even the way our society supports national goals are dependent on the US maintaining a leading-edge electronics industry.

Military. Electronics is the key to sustaining US superpower status. It has transformed the way we plan and fight wars, primarily through relying on COTS solutions to military needs. However, reliance on COTS has dramatic security implications. The COTS acquisition strategy means that the US margin of advantage is thinner in the electronics domain. The Joint Vision 2010 tenet of "Information Dominance" is being challenged by the worldwide proliferation of secure, state-of-the-art command, control, communications and computer (C4) systems. As long as COTS solutions are driving the DoD acquisition process, adversaries must be assumed to possess near parity in the C4 warfare arena and to be approaching equality in other electronics areas, as well.

The pace of COTS electronics technology turnover is forcing a revolution in the military's resourcing strategy. DoD's lengthy acquisition process denies the military the benefits of the electronics sector's rapid turnover cycle. This can be addressed with acquisition strategies that mimic the commercial sector's focus on quick-turn developments. Weapons warehousing policies must be reassessed to assure that sufficient surge capability exists to meet peak demands.

Economic. The economy is riding the wave of the explosive growth of the electronics industry. Computer, semiconductor, and software sales are growing at phenomenal rates; the multiplier effect of these sales contributes to overall economic productivity and growth.

The emergence of international alliances among electronics companies will influence government decisions on aid, warfare and even embargoes. Governments will lose control of technology transfer among international partners and thereby minimize US technological advantage on the battlefield. Global interdependence and joint ventures will force a redefinition of what it means to "buy American"; DoD can no longer rely exclusively on US suppliers of warfighting capability.

Social. The electronics industry is revolutionizing the way society views and reacts to the environment; the social implications are enormous. Instantaneous access to news frustrates attempts at censorship and forces governments to provide immediate responses to world events to sustain public support for major national endeavors such as war.

Perhaps the biggest social challenge the electronics industry has is the public perception of warfare as video games where fighting is sterile and precision weapons only kill the "bad guys". Instant electronic exposure to the up-close and personal warfare conducted by terrorists and desperate nations could erode national will and prompt decisions based on public emotions rather than objective military parameters.

CONCLUSION

The electronics industry will continue to influence America's economy and national security, playing an ever-increasing role in the design and structure of systems of national importance. The significant shortage of skilled electronics industry professionals is a particular concern. The educational system is challenged to provide better-qualified workers while the industry develops elaborate schemes to attract and retain skilled workers in this highly competitive field.

The escalating electronics content of major weapons systems has increased both their lethality and their propensity to become obsolete quickly. This dilemma creates problems in the development and life cycles of major systems, requiring reevaluation of weapons acquisition practices. The sharply reduced defense acquisition budget has caused companies to rely on the commercial sector for business, moving DoD from its previously favored position to being just another customer.

Unconscionable delays in the issuance of export licenses hamper efforts by US companies to sell leading-edge technologies in the world market. Export licensing procedures must be streamlined to assure that the US remains a world leader in electronics innovation and marketing.

America's dominant role in world politics and economics and military affairs demands continuing development of innovative, world-changing products. For the electronics industry to remain a world leader,

it is imperative that industry and government work together synergistically. Ultimately, the electronics industry has the resources and the dynamic promise to make an unprecedented contribution to the US economy and national security.

The potential and pace of the electronics industry compares to the Industrial Revolution that swept the world at the turn of the 20th century. America's success in the next century will depend on how well the nation addresses the challenges outlined in this report and achieves the promise of this critical sector.

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ENERGY

ABSTRACT

Energy is a global commodity and the lifeblood of modern economies. Prosperity in America depends on our ability to manage energy to strengthen the competitiveness of our economy, protect our environment, and keep our nation secure. Reliable and affordable energy supplies maintain the lifestyle Americans enjoy. The study group is proud to report that the US energy industry is vibrant, strong, and dynamic. This report is forward-looking in that it addresses the significant challenges facing the nation during the next 20 years and recommends policy for future action. The group's recommendations focus on the following goals: proactive support to the energy industry, balancing economic prosperity with environmental protection, and ensuring international energy security. Additionally, the group offers specific thoughts on securing the energy resources in the new frontier of the Caspian Basin.

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PLACES VISITED

Domestic

Baltimore Gas and Electric, Nuclear Power Plant, Calvert Cliffs, MD
British Petroleum Solar Plant, Fairfield, CA
California Public Utilities Commission, San Francisco, CA
Chevron Corp. Richmond Refinery, Richmond, CA; San Francisco, CA
CONSOL, Inc., Blacksville #2 Mine, Morgantown, WV
Enron Corporation, San Francisco, CA
Exxon Company USA, Santa Ynez Unit, Santa Barbara, CA
National Museum of American History, Alaskan Pipeline Exhibit,
Washington, DC
Natural Resources Defense Council, San Francisco, CA
Ogden Martin's Systems of Montgomery, Inc., Dickerson, MD
Pacific Gas and Electric Company, San Francisco, CA
Potomac Electric Power Company, Generating Station, Dickerson, MD
Solarex, Frederick, MD
US Department of Energy, Washington, DC

International

American Embassy, Baku, Azerbaijan
Amoco Corporation, Baku, Azerbaijan
Azerbaijan International Operating Company (AIOC), Baku, Azerbaijan
BP Oil, Baku, Azerbaijan
The BP and Statoil Alliance, Baku, Azerbaijan
Ministry of Defense, Baku, Azerbaijan
Ministry of Foreign Affairs, Baku, Azerbaijan
President of Azerbaijan, Heydar Aliyev, Baku, Azerbaijan
American Consulate, Istanbul, Turkey
American Embassy, Ankara, Turkey
Amoco Corporation, Ankara, Turkey
BOTAS Petroleum Pipeline Corporation, Ankara, Turkey
BP Turkey, Istanbul, Turkey
DEIK, Foreign Economic Relations Board, Istanbul, Turkey
Ministry of Energy and Natural Resources, Ankara, Turkey
Ministry of Foreign Affairs, Ankara, Turkey
TEKFEN, Istanbul, Turkey
Trakya Elektrik, Marmara Ereglisi, Turkey
Turkey Electricity Distribution Company, Ankara, Turkey
Turkish Foundation for Combating Soil Erosion, Istanbul, Turkey
Turkish General Staff, Ankara, Turkey
Turkish State Oil Company, Ankara, Turkey
Turkish Straits Harbor Master, Istanbul, Turkey

INTRODUCTION

"Energy is the lifeblood of modern economies" (US Dept. of Energy, 1998a, p.2).

Energy powers our factories, heats and cools our homes, and moves people and goods. Reliable, affordable energy supplies maintain the prosperity of the US. Promoting prosperity is a key core objective of the US National Security Strategy (NSS). Energy is also a global commodity, subject to a global market that drives prices and determines product availability.

In this report, the Energy Industry Study Group assesses US access to energy sources and analyzes America's ability to use energy efficiently. Two of the major challenges facing the energy industry are managing the delicate balance between protecting the environment while continuing to grow our national economy and assuring worldwide energy security.

Overall, the American energy industry is robust, healthy, and diverse. Ample capacity exists, or is planned, to support our aggressively growing economy. Automobile emissions are dropping while coal and natural gas-fired electrical power plants are producing ever-decreasing levels of environmental pollutants. Equally impressive is the industry's rapidly developing technology. The quality of this maturing technology is a tribute to the competitive nature of the American economy. Competition is also fueling the effort to reduce emissions harmful to the environment while driving costs lower. This competition is in direct contrast to the way electricity is managed in some parts of the world where oil and natural gas production and distribution companies are owned by the state. These organizations have little incentive to build new capacity, develop new technology, or reduce costs. Thus insufficient electricity, with the specter of regular blackouts, restricts much needed economic growth.

This report concludes with four recommendations that will ensure an aggressive, viable, US energy policy: provide proactive support to the energy industry; balance environmental and economic considerations; pursue international energy security; and develop and implement a coherent Eurasian policy.

THE ENERGY INDUSTRY DEFINED

Energy is consumed by four basic sectors of our economy: transportation, industrial, commercial, and residential. A significant amount of energy is used to produce electricity that powers the industrial, commercial, and residential sectors. This study focuses on the transportation sector and on the production of electricity that combined accounts for over 60% of all energy consumed in the US (Dept. of Energy, 1998a). US policy and market decisions affecting these areas can dramatically impact our economy, the environment and national security.

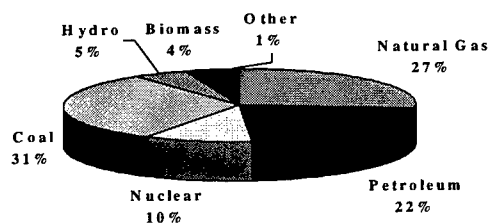
The energy industry is made up of two major components: development and production of raw energy products (for example, coal, oil, and natural gas) and refinement, conversion, and distribution of energy services such as electricity or gasoline for consumer consumption.

Energy Sources

The following figure shows the percentage of energy production by fuel.

Figure 1. US Energy Production by Fuel

U.S. Energy Production by Fuel



Energy Uses

Coal. Coal provides 23% of America's energy. Coal is plentiful and is one of the least expensive energy sources for generating electricity. Through 2020, coal will supply the energy to generate more than half of the electricity in the US (Energy Information Administration, 1997a). The US contains 24% of worldwide recoverable coal reserves, estimated

to be 1.1 trillion tons. At current production levels, US coal reserves will last more than 250 years (Power Engineering). However, the US will need nearly 30% more electricity by the year 2010—an increase of 150,000 to 200,000 megawatts (Power Engineering). Clearly the demand for coal is growing. Projections show coal consumption for electricity generation rising from 896 million tons in 1996 to 1.1 billion tons in 2020 (Energy Information Administration, 1997a, pp. 65-66). Much of that added capacity is expected to come from coal because of its availability and low cost.

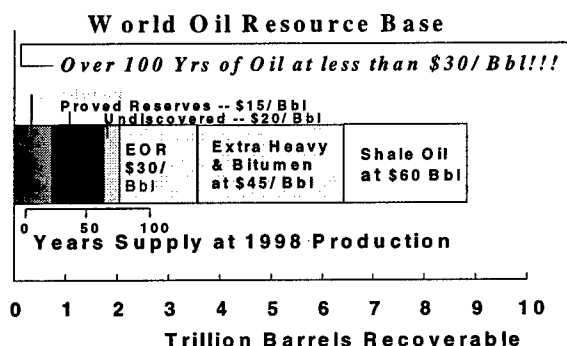
Market pressures are forcing the US coal industry to consolidate. To remain competitive, the industry must steadily increase productivity while reducing costs. The solution to this challenge lies with improved coal mining technology. New mining technology, such as improved long wall mining equipment, is revolutionizing underground mining and dramatically increasing productivity. During the study group's visit to Consol's Blacksville #2 Mine in Morgantown, West Virginia, the group witnessed this impressive technology in action.

Oil. Oil provides 39% of America's energy. Sixty-six percent of the oil used in the US supports transportation (Dept. of Energy, 1998b, p. 40-49). Currently the US consumes approximately 18 million barrels of oil each day of which 48% is imported (Energy Information Administration, 1997c). Consumption is expected to increase at about 1.2 % annually and by 2020, the US could import 66% of its oil (Energy Information Administration, 1998). Crude oil prices fluctuated between \$13 and \$26 per barrel during 1997-98. Over the long-term, through 2020, many experts project a similar price band (Dept. of Energy, 1998b).

Proven world oil reserves are estimated at 1.1 trillion barrels of oil. At current production rates, this oil reserve will meet world oil demand for about 45 years (*US Industry and Trade Outlook*, 1998). However, as prices rise, additional sources of oil become economically viable; at \$30 a barrel, more than 100 years of oil are recoverable (see Figure 2).

New technology offers the opportunity to increase the amount of known oil reserves. Domestic oil production remains very competitive, requiring innovative technology to expand production while reducing costs. Three and four-dimensional seismic techniques identify potential oil reservoirs with a higher probability of producing oil. Directional drilling and deepwater oil extraction incorporate methods to produce oil from areas once considered out of reach and a new air injection technique shows promise for increasing production ('Oil Rig', 1997).

Figure 2. World Oil Resource Base



The oil refining industry continues to consolidate under strong market pressure and low product margins. Investments to refine heavier grades of crude oil containing higher sulfur content, along with debottlenecking and adding catalytic cracking equipment, are improving the economics of refining, particularly in a low-price crude oil environment.

For more than 25 years, arguments have been made that excessive dependence on imported oil is a potential threat. Loss of these imports could not be offset from increased domestic supply, or through the substitution of an alternative fuel. However, this perceived threat may not be as serious as once believed. The urgent financial requirements of all oil exporters make it unlikely that a major oil exporter would deny supply to the US market. Additionally, the efficiency of worldwide oil markets and the growth of financial trading tools make it unlikely that a hostile producer could target one purchaser by curtailing supply. Today's global market would respond with a higher global market price to allocate the reduced supply to all purchasers.

This is not to suggest that our national policy should ignore the impact of future threats to the world oil supply. The mere perception that the world oil supply might be disrupted is enough to cause a major price increase. This occurred in October and November of 1990 at the onset of the Gulf crisis. Within hours of the first air strike against Iraq, in January 1991, President Bush announced that he was authorizing a drawdown of the Strategic Petroleum Reserve (SPR). The SPR was created to give the US the freedom to act during periods of short-term supply disruption, or when supply is threatened. Crude prices plummeted by nearly \$10 per

barrel in the next day's trading, falling below \$20 per barrel for the first time since the invasion of Kuwait (Holt and Davis, 1997).

Particularly impressive is the oil production and refining industry's commitment to the environment. For example, the study group found Chevron's and Exxon's oil production and refining facilities environmentally sound. Efforts by both of these companies to operate without negative impact on the environment set an example for all of American industry. American and other western oil companies, operating in the Caucasus Region, are now exporting these western procedures and environmental standards where they were previously lacking.

Natural Gas. Natural gas is a growing source of energy for the US, and will rise from 21% of total energy consumed in 1998 to 28% by 2020 (Energy Information Administration, 1997e, p.xi). The restructuring of the electric utility industry will open new opportunities for natural gas-fired generation and natural gas will play a key role in the development of electric power. Use of natural gas by residential, commercial and industrial consumers is expected to increase at slightly less than one percent annually through 2020. Residential and commercial customers should expect gas prices to decline through 2020 due to lower transmission and distribution costs, increased utilization of pipeline capacity, and increased competition resulting from restructuring (Energy Information Administration, 1997e, p.xii).

Compared to traditional coal-fired electrical power generation facilities, natural gas-fired power plants are becoming increasingly popular since they often require lower capital investment, shorter construction lead-times, and are more environmentally benign. Further, technological advances are lowering operating costs. Finally, industry restructuring reduces the wellhead price of natural gas while domestic gas reserves are abundant and secure.

The innovative use of cost saving technology and expected additional natural gas discoveries, particularly in the deep water of the Gulf of Mexico, encourages greater interest in this area. Natural gas reserves are not geographically concentrated like oil. In many areas, deposits of gas are known to exist but are not counted as reserves because the infrastructure needed to gather and distribute the gas is not available. Lack of infrastructure (pipelines) is a major barrier to increased worldwide gas consumption. Since most natural gas moves by pipeline, natural gas utilization requires market proximity to its source. Technology advances in delivery and storage systems will be vital to improving the economics of natural gas as a source of fuel for expanded energy consumption.

Nuclear Energy. Nuclear fission provides about 22% of the electrical power in the US (Energy Information Administration, 1997b). Since 1978, no additional nuclear plants have been ordered and over 100 planned reactor starts were canceled, including all ordered after 1973. However, even though the nuclear power industry in the US is stagnating, American companies continue to develop improved, more efficient, and safer systems. These advanced systems generate less waste, and, significantly, do not lend themselves to weapons proliferation purposes (Domenier). Other countries are taking advantage of these improvements and building nuclear power plants utilizing American designs. Nevertheless, no new reactors are being built in the US.

Concern about safety and waste disposal hamper the future of nuclear power in the US. The devastation associated with a nuclear war, along with the accident at Chernobyl, planted a negative image of nuclear power in the public consciousness. Although minimal radiation was released, the incident at Three Mile Island also contributed to this negative image. The probability of a severe nuclear accident in the US is less than 1 in 10,000 reactor-years of operation (Holt and Davis). Educating the public about the safety of using nuclear energy to generate electricity can begin to address this concern. The regulatory licensing and bureaucracy associated with developing a nuclear power plant significantly raise the cost of capital. However, operating costs are relatively inexpensive, so reducing the bureaucratic burden and improving the industry's image could make nuclear power more economical and politically acceptable.

Nuclear waste disposal is more of an education and image problem than a technical challenge. Congress selected Yucca Mountain in Nevada as the first central nuclear waste repository. Pending further studies to ensure that this location is suitable, initial operation is not expected until 2010 or later (Wolfe). Current spent fuel storage capacity is adequate at the few regional sites in the southwestern US, coupled with on-site storage facilities at most of the nuclear power plants. The physical requirement for spent fuel storage is not significant. If the spent fuel from over three decades of nuclear power plant operations were collected on a football field, it would only be nine feet high (Wolfe).

Nuclear fuel supply is not a concern. The Department of Energy (DOE) plans to sell or transfer surplus defense inventories to the private sector for commercial use. These quantities, along with the uranium obtained from dismantled Russian warheads, provide for a large reserve of fuel for nuclear power plants. Additionally, spent fuel rods can be reprocessed. This reclaims about 80% of the fuel for reuse in a reactor and reduces requirements for waste storage facilities. Unfortunately, a

byproduct of this process is weapons grade plutonium, which could contribute to the proliferation of nuclear weapons. For this reason, reprocessing spent fuel rods is illegal in the US.

Shortly before the group's visit to the Calvert Cliffs Nuclear Power plant, Baltimore Gas and Electric (BG&E) became the first nuclear utility in the nation to apply for an extension of its current licenses that expire in 2014 and 2016. BG&E estimates that its nuclear facility can function for an additional 60 years. The success or failure of Calvert Cliffs' licensing renewal process will be watched closely by the nuclear power industry.

Renewable Energy. Hydroelectric, solar, wind, geothermal, and biomass are all renewable sources of energy. As a group, renewable energy sources provide 7.5% of the energy consumed in the US, with hydroelectric power providing 50% of that figure (Energy Information Administration, 1997e, p.4). Employing current technology, solar, wind, geothermal, and biomass are not economically competitive for powering the electrical grid. However, in the niche market for electrical power, at remote locations away from the grid, solar power is cost effective. For instance, Enron and Amoco, in a joint venture, produce conventional silicon photovoltaic cells in Frederick, Maryland, while a British Petroleum plant in Fairfield, California is preparing to produce photovoltaic cells using a state-of-the-art technology called "thin-film." Executives from both operations see a very bright future for photovoltaics as they continue to develop this cost-effective technology with reduced costs.

The rate of growth in the development of renewable energy depends on five major factors. These include growth of both the US and the world economies; extended disruptions in supply or a significant price increase in coal or natural gas; regulatory guidance as the electric utility industry restructures; technical advances and cost reductions in renewable energy technology; and the level of support for renewable energy by citizens (Union for Concerned Scientists). The principle of supply and demand ensures that as fossil fuel prices rise, other energy sources become more economically feasible to develop.

Energy Consumption

Transportation. America's per capita consumption of petroleum is by far the largest of the developed world. The most significant growth in US energy usage is projected to be in transportation (Energy Information Administration, 1998h, p. 40) Consider these statistics to put this in perspective. Transportation accounts for 26% of the total energy use of

our nation. This sector accounts for about 67% of all petroleum use in the US, and the fuel source for 97% of the transportation sector is from oil. Transportation is a vital element in the nation's economy and hence a national security concern.

Technological breakthroughs that affect our energy infrastructure often take decades. However, a robust energy R&D program is vital to protecting a healthy and prosperous future. To the extent that we choose economically attractive, clean and efficient technologies, both the economy and the environment can benefit. Such technological breakthroughs are rapidly becoming a reality in the transportation sector. DOE reports that by 2010 technology will exist to support competitively priced personal vehicles, capable of three times the fuel efficiency of conventional vehicles. Also, lighter, cleaner heavy-duty vehicle engines, advanced aircraft engines and airframes, and fuel cells for transportation could possibly be in use by 2005.

By 2010, we could be driving affordable cars averaging 80 mpg, emitting virtually no pollution, with the acceleration, driving range, safety and other performance characteristics of today's cars. The technology making this possible completely reinvents how vehicles are powered, designed and built. The two most promising technologies are the hybrid electric vehicle (HEV) featuring an internal combustion engine combined with batteries and the fuel cell.

Technologically, the HEV is further along in development. These vehicles have dual power sources. The primary power comes from the engine, but the batteries provide extra power for acceleration and store electricity generated by the engine. These HEVs will achieve at least triple the fuel economy of today's engines and will produce lower emissions. The HEV does not require external recharging, a detractor of the simple electric vehicle. Furthermore, the battery supplements the engine when acceleration or hill climbing are required, thereby allowing for a much smaller and more fuel-efficient engine than conventional cars. The net effect is a car capable of twice the range of today's cars, with four times the efficiency, and with only a fraction of the emission levels. HEVs could provide the size, safety, and acceleration characteristics that Americans demand.

Fuel cell technology requires further development, but offers additional advantages. It converts fuel, such as hydrogen, directly into electricity powering an electric motor to drive the vehicle. Fuel cells are much more efficient than standard internal combustion engines. They emit small amounts of pollutants, have no moving parts, and yet are silent and almost maintenance-free.

Both the HEV and the fuel cell power systems approaches could be used for a wide range of vehicles. This includes trucks, buses, and commercial vehicles as well as passenger sedans and sport utility vehicles. Fuel cell vehicles are expected to be 70-90% cleaner than today's cars. If they comprised just 10% of the US vehicle fleet, they would reduce oil imports by 130 million barrels per year. Although several auto companies have built prototypes of these new vehicles, they are not ready for commercial production. Fuel cells must be made smaller, lighter, and less costly to be economically viable. However, the pace of development is accelerating and these new vehicles are likely to begin rolling off the assembly line and onto the highway early in the 21st century (Motavalli, p.34).

To promote rapid introduction of HEVs, national policy could provide limited tax credits to offset the cost of HEV introduction until prices are competitive with conventional cars. Consumers will recover the initial cost difference through fuel savings after a few years. The current administration is reviewing a tax credit policy of up to \$4000 for purchasers of cars that get two to three times the current gas mileage of cars in their size class (Business Council of Sustainable Energy, p. 2). Such a policy could provide the necessary incentives to accelerate the introduction of new technologies into the marketplace on a much larger scale.

Electricity Production. Total retail sales of electricity in the US in 1996 reached 3 trillion kilowatt-hours (kWh). Revenue from the sale of electricity reached \$225 billion. The average cost to consumers was 6.87 cents per kWh, a decrease of 0.06 cents compared to 1995 (Energy Information Administration, 1997d, p.5). Nationally, the per kWh costs vary from 4 cents in Idaho to 10.5 cents in some northeastern states.

The per capita demand for electricity is projected to increase an average of 0.5 % from 1995 to 2015 (Energy Information Administration, 1997g, p.1). Summer peak demand is projected to increase by an average of 1.7% over the same period (Pennwell Power Group, p.4). This continues a downward trend that began in the first half of the 1990s. Increases in appliance efficiencies and standards, and industrial awareness of energy costs, slowed the growth of electricity consumption. Demand is now lagging behind economic growth. This trend of demand growing slower than the economy is expected to continue over the next two decades (Pennwell, p. 3). However, it is interesting to note that according to the Energy Information Administration, all energy forecasts in past years have overstated future prices, particularly in the 1970s and 1980s. The major factors for these

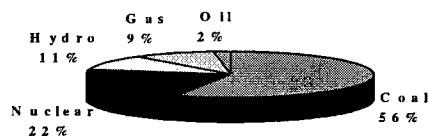
errors were increased competition, technological advance, and decreased demand.

Electric power is a \$225 billion industry comprised of over 3,000 utilities (Kwoka, p.7). The industry is divided into three functions: generation, transmission, and distribution. Each utility performs one or more of these functions and those that do all three are said to be vertically integrated.

As depicted in the chart (see Figure 3), most electricity is generated using fossil fuel combustion to create steam that powers turbine generators. Considerably less electricity is produced in nuclear power plants that rely on nuclear fission to create steam. Hydroelectric plants that use the flow of water to turn turbine generators produce even smaller amounts of electricity. Small-scale gas turbine generators are used by most utilities to produce additional electricity during peak periods.

Figure 3. Sources of Electricity

**Sources of Electricity
Generation in the United States**



Transmission involves the long distance flow of electricity from generating station to wholesale purchaser. The generating station must send the electricity at high voltages to minimize losses due to the physics of electrical current. High voltage lines require substantial capital and secure rights-of-way over long distances.

Local distribution lowers the voltages from the transmission lines and delivers it to individual customers. Distribution includes the wires located along streets and involves substantial capital and rights-of-way. Distribution also encompasses sales and the commercial functions of securing supply, marketing, billing, and customer service.

State of Technology

Vertical integration has historically been the rule in the electricity industry. Bigger was always better because the cost to build a larger generation facility was not proportionately more than the cost to build a smaller facility. However, recent experience is at variance with this pattern. The real construction costs of coal-fired plants rose more than 100% between 1962 and 1982. Part of this cost increase includes new technology, environmental protection constraints and lower productivity at the construction site (Dowlatabadi, p.27).

Advanced technologies for the construction of new plants now include modular designs that are smaller in size and are largely assembled in factories before shipment to the plant site. The real benefit of these new designs is a gain in economies of scale, reducing unit cost.

Other advances include the low-emission boiler system (LEBS) and the high performance power system (HIPPS) for coal-fired plants. The goal of the LEBS is to reduce nitrous oxide, particulate and sulfur emissions, raise thermal efficiency, and lower the cost of electricity generation. The goal of HIPPS (a longer term program) is to raise thermal efficiency through the use of more exotic technology. Fluidized-bed combustion is another technology that shows promise for coal-fired plants in the future. These technologies tend to reduce pollution while increasing efficiencies (Pennwell Power Group, p.155).

Advances have also been made in nuclear generating technology. General Electric developed the Advanced and Simplified Boiling Water Reactors and Westinghouse developed a smaller Simplified Reactor (Pennwell Power Group, p. 176).

Natural gas is the fuel of the future for the electricity industry. Advances include the gas turbine-based combined-cycle technology, which is proving to be the best. Thermal efficiency is highest in plants using this technology, an efficiency that cannot be approached using any other technology (Pennwell Power Group, p. 285). The future will bring gas micro-turbines into homes and businesses to generate electricity internally.

Deregulation of the Electrical Industry

The major challenge facing the industry today is deregulation. Historically, this industry was considered a natural monopoly where a single company could provide service more efficiently. Recently, due to rapidly rising costs to the consumer in the 1970s and 1980s, many believe it is time to introduce competition into the electricity market

through deregulation. Deregulation, once fully implemented, will bring fundamental change to the industry (Joskow and Schmalensee, p.7). Fourteen states including California, New York, and Arizona have already enacted statutes that will create a competitive retail access market. Eleven states have pilot projects to test retail competition (Energy Information Administration, 1997d, p.3).

Electricity deregulation could provide a significant boost to the US economy. An increase in the gross national product of \$160 to \$190 billion and tax revenue of up to \$50 billion annually is projected. For the consumer, as typified by the telephone, trucking, and airline industries, deregulation could reduce the delivered price of electricity by 45% (Maloney, McCormick, and Sauer, p. xxiii).

Deregulation sparks competition. First, competition tends to stimulate more efficient utility operations and a lower delivered price, thus benefiting consumers economically. Second, competition tends to provoke a more efficient industry structure by encouraging specialization in either generation or distribution. A more efficient structure would contribute to higher production levels and lower prices. Third, competition tends to reduce price differentials among utilities, thereby contributing to more equal pricing across the nation as electric power becomes a tradable commodity. Collectively, these benefits could ultimately strengthen the US economy.

CHALLENGES

Energy and Environment

The energy that provides our economic lifeblood is also a major source of environmental pollutants. Burning fossil fuel produces toxic gases, volatile particulates, and greenhouse gases. These emissions not only impact human health, but *may* also cause global warming. Future energy strategy should address a diverse portfolio that still includes a major dependence on fossil fuels for decades to come. However, that strategy must also address the environmental consequences and the efforts to reduce them.

To maintain an abundant and economically affordable energy supply that is environmentally benign may require governmental action and intervention. Several regulatory and policy actions have reduced pollutant emissions such as sulfur dioxide, nitrous oxide, and many particulates. The Clean Air Act Amendments of 1990 and the Environmental Protection Agency's (EPA) recent publication of National

Ambient Air Quality Standards are examples. Additionally, developing and promoting new clean energy technologies, increasing energy efficiency, and promoting market incentives could improve the quality of our environment. The energy industry is already pursuing many of these approaches.

Coal. The economic future of the coal sector appears sound, although it is challenged by environmental difficulties. Coal combustion emits more pollutants per unit of energy than any other fuel. However, significant progress has been made. Current technologies can capture more than 95% of sulfur dioxide emissions and 99.5% of particulates emitted. Nitrous oxide emissions can also be substantially reduced with new burner technologies (Union of Concerned Scientists, p. 47).

The coal industry has embarked on an ambitious technology effort that includes pre-combustion cleaning and chemical treatments; new combustion methods such as Atmospheric and Pressurized fluid bed combustors that significantly reduce sulfur dioxide and nitrous oxide emissions; post combustion "scrubbing" of sulfur emissions; and new techniques to convert coal into a gas or liquid that can be cleaned and then burned (CT, pp. 24-26).

Oil. Environmental concerns over oil include both the upstream (exploration and production) and downstream (pipelines, storage, refining, and marketing) phases in addition to emissions from burning petroleum derived products. The debate between environmental groups and oil companies limit oil drilling sites in the US. The result of this debate is an improved environment from exploration to filling station.

Even though gasoline powered vehicles are more than 90% cleaner than they were a generation ago, they continue to be a major source of environmental emissions. Eighty percent of petroleum-related emissions are from transportation (Energy Information Agency, 1997c, p. 28). The projection through 2020 is that Americans will increase their travel by about 2% per year, resulting in more carbon emissions. Even with cleaner engines, carbon emissions will continue to grow by 2020.

Natural Gas. Natural gas is the cleanest of the fossil fuels and the administration is promoting it as a primary source for US electricity generation. Natural gas has almost no sulfur or particulate emissions, less nitrous oxide emissions, and almost half the carbon dioxide emissions of coal. Natural gas has a significant place in the US energy / environmental balance (Energy Information Agency, 1997c, p. 28). To be economically competitive, natural gas power system efficiency must be increased from 50 -70% .

Nuclear. One of the cleanest of all electric generating fuels is nuclear power. These power generation systems emit no atmospheric

pollutants or greenhouse gases. The spent radioactive fuel rods pose minimal threat to the public and can be contained in a relatively small area. However, as previously discussed, it is virtually impossible to develop new nuclear power plants domestically. Nuclear energy remains an exceptionally safe and environmentally sound electricity-generating source, but will require extensive public education to restore confidence in its safety.

The problem of carbon dioxide and other greenhouse gas emissions received much attention as a result of the Kyoto Protocol as part of the United Nations Framework Convention on Climate Change. Under this protocol, the administration agreed to reduce the emission levels of most greenhouse gases to 7% below 1990 levels. To date, the Senate has not ratified this protocol. Additionally, the debate continues within the scientific community as to whether global warming is occurring.

Nevertheless, the Kyoto goals will be difficult to reach. In 1990, carbon emissions in the US amounted to 1.3 billion metric tons and are projected to grow 1.2% per year to nearly 2 billion metric tons by 2020 (Energy Information Agency, 1997c, p. 28). This exceeds the target by more than 52 percent. An international emissions trading program and offsets for carbon dioxide sequestration provide some flexibility. To maintain economic prosperity, a longer timeframe than the current proposal of 2008–2012 may be required.

A responsible energy policy requires a balance between economic and environmental concerns. Promoting a serious environmental program, and satisfying a strong demand for energy, can be complementary. While it may take longer than desired, new technologies, increased efficiencies, and market based consumer and industry incentives could provide the desired results.

Regional Stability

The Persian Gulf region has long been the world's largest supplier of both oil and instability. Now joining this club with lesser but still substantial amounts of both products is the Caspian Sea region of the former Soviet Union. Comprised of six Islamic and two Christian countries, this region stretches from the Black Sea in the west to China in the east. It includes the Caspian Sea itself, is flanked north and south by aggressive neighbors, and is blessed with oil and gas reserves estimated to equal one third of those contained in the Persian Gulf. It comes equipped with a legacy of centuries of strife (ethnic, cultural, dynastic etc.), previously suppressed by the Soviet Union, but now free to once again seek resolution through conflict. Moreover, the region is

landlocked and saddled with a primitive transportation infrastructure. Yet, international oil companies believe there is an abundance of oil and gas in the region still to be extracted and are investing in all phases of its commercial development.

Quick to recognize the opportunity created by the new political structure, various consortia of international oil companies have established contracts with the several governments. Their goal is to extract the oil and gas, purvey it into the world market, and gain a share of the region's enormous potential wealth. Further, their vision is long-term; most companies anticipate 30-year lease agreements. Their capital investment is accordingly substantial and so are their challenges. Not only must this oil and gas be located (yet to occur for the most part), but it must also be economically delivered to the market. Making the economics work will be just one problem; this task must be carefully woven through varied regional tensions for which there seems to be no clear resolution.

Most of the oil and gas reserves in the region are thought to be located under the Caspian Sea, or near onshore. Many potential oil and gas structures have already been identified under the seabed, but the actual exploration for the resources awaits adequate equipment. Drilling rigs and other necessary equipment within the region are scarce. The equipment that does exist is in poor condition and badly in need of overhaul—the Soviet Union having long since abandoned the area in preference for Siberian oil. Furthermore, much of the area is an environmental disaster and dramatically reflects the 100 years of Czarist and Soviet Russian exploitation. Finally, existing regional pipelines all travel through Russia, holding the new countries and their economies hostage.

Russia itself, still smarting from its diminished world position, applies as much regional pressure as it can muster to maintain a regional hegemony. It views all of the Newly Independent States (NIS) as its "Near Abroad" and still within its exclusive sphere of influence. In resistance to this pressure, the NIS seek international engagement, primarily with the West. To the East and South, loom China and Iran, each with its own baggage vis-à-vis the West. Furthermore, relations between and within these new republics cover a large spectrum, with open warfare and closed borders often the norm. The difficulty these tensions impose on the economic extraction of oil are complicated and endemic. They are unlikely to cease for some time.

A regional bright spot, however, is Turkey. Located at the western edge of the Caspian region, it offers a viable, nonhostile route for the transport of oil and gas to the world market. Long a member of NATO,

and a US ally in the Korean War, Turkey is a model for the regions new republics. With a secular democracy since 1923, it offers a viable alternative to the Islamic Republic model, so disruptive to regional stability. Additionally, since the reforms of Turgut Ozal in the 1980s, Turkey's economy has experienced substantial growth. Turkey is now a member of the European Customs Union and continues to seek full admission to the European Union. This westward affiliation is a deliberate state policy and serves to stabilize the region. The West could capitalize on this opportunity by being more receptive to Turkey's interests, thereby reinforcing its link to the West.

Given the options, the most viable route for extracting Caspian oil appears to be a pipeline through Turkey. Such a pipeline could outflank both Russia and Iran. This plan will meet resistance from many regional actors for political and economic reasons. Yet, with the amount of crude oil and gas forecast to be moved within 10 years, no other route is as attractive. The Bosphorous is simply too constrictive, with enormous environmental risk. Turkey will properly resist this threat to its largest city of Istanbul. Other routes, again, would have to transit hostile nations. Although expensive at \$2.5 billion, a pipeline through Turkey to Ceyhan on the Mediterranean Sea resolves most difficulties while reinforcing Turkey, a most valuable ally.

OUTLOOK

The energy sector of the world economy has a profound impact on global economic growth, international security, and worldwide environmental quality. Energy is a global commodity. As such, the US energy policy affects everyone.

GOVERNMENT GOALS AND ROLE

As the remaining superpower, the US must lead the effort to ensure that the world economy has an unrestricted energy market. In this leadership role, the US must articulate coherent policies to proactively support the energy industry, strike a balance between the environment and the economy, ensure international energy security, and foster regional stability throughout the world.

Proactively Support Energy Industry

With energy the lifeblood of the economy, the US must be proactive in supporting the energy industry. A strong viable energy industry enhances American competitiveness across the board. The US should:

- Implement innovative tax policy that continues to provide broad incentives for industry to tackle energy technologies not yet economically competitive.
- Fund basic research of the underlying science supporting cutting-edge energy technology. This funding will contribute to American competitiveness in the global economy.
- Enact legislation to accelerate deregulation of the electric utility industry. Markets unencumbered with government regulation foster competition which rewards innovation. Unbundling the generation, transmission, and distribution of electricity and allowing competition where possible will lead to tremendous efficiencies. Unbundling will benefit all Americans by improving their standard of living through lower prices and improved service.
- Streamline the regulatory licensing and building approval process for nuclear power plants. Aggressively pursue responsibly educating the American public on the benefits of nuclear fission as a viable, safe, and low cost source of energy.

Balance Environmental Considerations with Sound Economic Policy

Climate change and other environmental issues present difficult challenges for the energy sector of tomorrow. No scientific or economic consensus exists on the actual environmental or economical consequences facing us in the future. Our environmental policy of tomorrow must allow for increasing domestic energy production in an environmentally responsible manner. The US should:

- Provide incentives to accelerate development and market adoption of environmentally friendly technologies. The policy must support increased investment in basic and applied research and include tax incentives for climate-beneficial investments. This will encourage industry to adopt new and existing technologies due to their economic benefits, while reducing greenhouse gases and other (US Dept. of Energy, 1998a). The policy should expand future energy choices by pursuing continued progress in science and technology to provide clean and reasonably priced energy sources.

- Support coal-fired electrical power generation plants by accelerating research on clean coal technology and intensify basic research on innovative systems for carbon cycle management. US coal supply is abundant (250 years) and it is the least expensive fuel for generating electricity. It should not be abandoned in pursuit of environmental goals that can be addressed through technological efficiencies.

- Expand the incentives for purchasing vehicles powered by alternative fuels. Technology is developing rapidly; however, demand must expand before it becomes viable for automakers to enter full production.

International Energy Security

The energy market is a global market. The extent to which the US effectively interacts on an international basis will determine how we fair economically on a domestic basis. Engagement and cooperation with foreign governments and promotion and deployment of clean and efficient energy systems worldwide are extremely important to the success of achieving US energy, economic, and environmental goals.

The US should:

- Reinforce the focus of the Strategic Petroleum Reserve (SPR) using it as a hedge against world oil price volatility. Management of the SPR should be reorganized to allow automatic market-based buy and sell triggers. Congress should resist the urge to fund the maintenance of the SPR by selling oil, especially at low prices. Rather, maintenance should be funded through the normal budget process.

- Pursue an effective policy on the responsible transfer of energy technologies in international cooperative activities (US Dept. of Energy, 1998a). International energy security promotes cooperation between the US and other countries.

- Diversify energy sources to provide the US and world markets with more options. American leadership and cooperation in pipeline developments around the world provide oil importing nations energy sources apart from OPEC.

- Encourage transnational corporations to participate in international collaboration with the US to develop and promote clean, safe, and efficient energy technologies. This would allow the US to participate in large-scale experiments while advancing the goals of American science and energy programs. This is key to remaining a world leader in basic energy research and in promoting

US national security objectives. US involvement in international energy resource development provides the international community with much needed diversification, reducing dependence on a single region for supply. This is vital to American national security objectives.

Eurasian Policy

The single most important step in fabricating a policy for the Eurasian region is to recognize its geography. From the Black to the Yellow Sea, and from the Aral to the North Arabian Sea, a vast area of Eurasia is captured. Most of the governments within this area are either authoritarian or fragile. They tend to share a familiarity with the failures of communism and a desire to join the market society of the West. Yet they also share centuries of animosity, jealousy, and paranoia. Their individual relations with each other and with the West fluctuate and remain largely unstable. Still, within this area, atop a potentially vast reserve of oil and gas, reside the Turks.

The Turks cut a swath of potential stability from Europe right through to the border of China. It is the Silk Road of the 21st century – or could be, if the US would only notice the dynamics of the region and fashion a policy supportive of regional stability. The Turks, of course, include all peoples of Turkic descent residing in central Asia, the Caucasus, Anatolia, and European Thrace. Of these, only Turkey itself has direct access to world maritime routes; the rest are landlocked. Several are located east of the Caspian Sea and together with Azerbaijan to its west, could form a block of stability with a western orientation. These countries, with their oil reserves, have the additional ability to contribute substantially to the global economy.

However, establishing such a block requires support as these countries seek to offset the influence of Russia and Iran. This is where US diplomacy could be most effective. Currently, there does not appear to be a detectable US strategy in place that recognizes the importance of this region. For instance, Azerbaijan, alone among the former Soviet states of the region, does not allow any Russian troops on its soil. Azerbaijan does not seek to become an Islamic republic even though more Azeris reside in Iran than in Azerbaijan and despite the close cultural ties. Rather, it seeks to strengthen its links with the West, particularly the US, and actively resists Russian encroachments. Yet, the US refuses to provide Azerbaijan humanitarian aid for its refugees because of its unsettled contest with Armenia, a Christian state to its west. This situation arises from domestic US political forces, but it is

both morally questionable and shortsighted. If a buffer between Russia and Iran is to be preserved, and the oil wealth extracted without providing either country further leverage, the US should revisit its current position. Azerbaijan is far too crucial to the larger stability of the whole region to be ignored.

Even more important to this goal will be the future of Turkey itself. Here is a true demonstration of national success without having become another nation's puppet. Turkey can easily be seen as the single most important country of the region. Its geographical position is central as it is the gateway to the East and crucial to maintaining regional control, as it has been for centuries. Thus, US should support Turkey in resisting regional pressures and internal instability. Turkey presents the only viable economic route for oil extraction from the Caspian region, given current US policy toward Iran.

From the Bosphorous to the Caspian, the potential exists for an economic and political belt that could project western values of democracy and free enterprise into Asia. Concurrent with this would necessarily come a band of states linked by common interests that could hopefully start to overcome some of the animosities that have plagued the region for centuries. Were this to occur, the energy demands of the global and emerging Asian economies could safely be sustained for many productive years, while the US would gain valuable allies in a critical region of the world.

CONCLUSION

The energy industry is a vital and dynamic industrial sector. It is the foundation of our nation's economy and critical to economic prosperity. Additionally, the industry has demonstrated a sense of responsibility for and commitment to national security. Concern for the worldwide environment and support for the Foreign Corrupt Practices Act are cornerstones of the industry. In fact, the energy industry is a leader in these areas. The study group was truly impressed by the creativity and dedication of the industry and its workforce. The future is bright! As the US moves into the 21st century, we will continue to be a major competitor in the global marketplace, and the energy industry will lead the way.

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ENVIRONMENT

ABSTRACT

The US environmental industry is a diffuse collection of services, manufacturers, and other resources — more than 115,000 firms and organizations in a \$450 billion global market. It is becoming less a distinct industrial sector and more a better business practice. For years, domestic pollution remediation dominated the industry. The progress of domestic cleanup and the fact that pollution prevention is often cheaper than remediation have refocused market opportunities overseas in pollution avoidance. Amidst this evolution, the US and other nations agreed in Kyoto in 1997 to fight global warming by reducing greenhouse gas emissions. This report addresses the state of the environmental industry and the impacts of implementing the Kyoto agreement in terms of competitiveness, market opportunities, and national security. It speaks to evolving and interrelated challenges in deploying new technologies, penetrating foreign markets, establishing and enforcing standards, and gaining multilateral cooperation.

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PLACES VISITED

Domestic

Aerovironment, Simi Valley, CA
ARCTECH Inc., Chantilly, VA
Bechtel Group, San Francisco, CA
CINCPACFLT, Headquarters, Honolulu, HI
Custom Print, Arlington, VA
Earthtech, Long Beach, CA
EDA/Geokinetics, Oakland, CA
EMCON, San Jose, CA
Foster Wheeler Environmental Corp., Los Angeles, CA
International Technology Corporation, Irvine, CA
Lawrence Livermore National Laboratories, Livermore, CA
Oceanside Water Pollution Control Plant, San Francisco, CA
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Thermatrix, San Jose, CA
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International

Center of Environmental Technology, Hong Kong
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Chep Lap Kok Airport Construction, Hong Kong
Environmental Protection Department, Hong Kong
Hong Kong Polytechnic University, Hong Kong
Hong Kong Productivity Council, Hong Kong
Central Pollution Control Board, New Delhi, India
Clean Technology & Environmental Management, New Delhi, India
Confederation of Indian Industry, New Delhi, India
Development Alternatives, New Delhi, India
Ministry of Environment and Forestry, New Delhi, India
Tata Energy Research Institute, New Delhi, India
US Agency for International Development, New Delhi, India
Global Plasma Systems Corp., Malaysia
Quality Alam Chemical Waste Treatment Facility, Malaysia
Selangor Nature Park, Malaysia
US – Asia Environmental Partnership, India, Malaysia, Hong Kong
US Embassies in India and Malaysia
US Consulate General in Hong Kong

INTRODUCTION

The national security of the US rests squarely on the strength of its economy and the personal health and welfare of every citizen. The 1970 Environmental Policy Act established this country's vision and policy for living in harmony with our environment, namely: ".... to create and maintain conditions under which man and nature can exist in productive harmony and fulfill the social, economic and other requirements of present and future generations of Americans."

Humankind and the natural environment are interdependent. As we have seen in recent years, there are negative consequences as man transforms the environment by clearing forests, burning fossil fuels, and tilling the soil. These consequences do not respect national boundaries. In a national security context, environmentally induced scarcities or direct threats may contribute to instability and conflict within and among nation-states, often involving transnational groups.

In December 1997, global warming came to the fore in the United Nations Framework Convention on Climate Change Conference in Kyoto, Japan. There is strong scientific evidence that people's recent and substantial addition of greenhouse gases (GHGs) to the earth's atmosphere has had a discernible impact on raising global temperature. In response to that finding, industrialized nations are cooperating to address the problem by adopting policies and implementing measures to limit GHG emissions and protect GHG sinks (e.g., forests that absorb CO₂ emissions naturally). Although the US Senate has not yet formally ratified the Kyoto Protocol, the agreement's provisions and targets for emission reductions are likely to be implemented as US policy.

This report addresses the state of the environmental industry and, more particularly, the nature and implications of global warming. It specifically looks at US industry and the impacts of implementing the Kyoto agreement and competitiveness and market opportunities for the environmental industry at home and overseas.

THE ENVIRONMENTAL INDUSTRY DEFINED

Defining the scope of the US environmental industry is not easy. The sector is large and highly fragmented. It is a diffuse collection of services, manufacturers and other resources focused on developing and applying technologies and processes in the world market for pollution avoidance, monitoring and assessment, control, and remediation. In the

US, it is becoming less a distinct industrial sector and more a set of better business practices integrated into every part of the economy.

Some 115,400 organizations (both investor-owned and government entities) provide products and services. Most are in the public sector, focused on providing potable water and wastewater treatment. In the private sector, most firms are in solid waste management services.

The global environmental market is large, valued at about \$450 billion in 1997 and growing at rates that outstrip the pace of growth in the US environmental market. The US market for products and services is estimated to range between \$141 billion and \$181 billion per year. Forecasts for the global market in the year 2010 are \$600 billion in annual revenues (Environmental Business Journal, 1997; Standard and Poor's, 1998).

Today, the US remains the leading global producer of environmental technologies with exports estimated at more than \$16 billion in 1996 alone. Still the US export market remains small at about only 8-9% of total output—considerably less than Japan and Germany's 20% estimated export share of their industries' revenues. European purchases account for approximately 33% of the \$450 billion global environmental market.

America also leads as the largest consumer of environmental goods and services. In 1996, the industry employed approximately 1% of the US workforce or 1.3 million Americans, while almost 24,000 new jobs were created in the US (US Dept. of Commerce, 1997).

The US environmental market grew at rates of 10-15% per year between 1985 and 1990 when regulations and demand were strong. Since 1991, weak demand, an absence of new federal regulations, and diminished state enforcement of federal regulations due to government downsizing have contributed to significantly lower growth rates, averaging about 5-6% annually. To cope with the market's decline, many leading environmental businesses have been forced to pursue consolidation. In 1996, annual revenue growth slowed to its lowest rate to date, 1.4% (Environmental Business Journal, 1997).

CURRENT CONDITION

Performance in Key Segments

Water Supply and Treatment. The US water supply and treatment segment, depending on how broadly or narrowly it is defined, ranged between \$74 and \$82 billion in annual revenues in 1996, showing growth

of between 4 and 5% between 1995-1996. It is the largest segment in the US environmental industry.

Industry analysts suggest that the water supply and treatment segment is a counterweight for the otherwise shaky \$181 billion US environmental industry (Environmental Business Journal, 1997). Opinions vary, however, as to whether the segment has potential for continued steady growth in the US. Some feel the segment's diverse customer types and its generally strong foundation offer promise for expansion. Others suggest that the water quality industry's principal sources of demand (e.g., industrial growth, population growth, environmental regulations and monitoring) will remain sluggish into the next century. With fewer federal regulations and less federal funding, growth in this already mature segment of the industry will probably only track inflation.

Like the solid waste management segment, more investor-owned companies (representing about \$32 billion of the segment) are consolidating operations and markets. Privatization opportunities seem to be increasing for shifting the operation of water facilities from municipalities (operated as local monopolies) to investor-owned operations. The assumption is that private industry can operate utilities more cheaply than local governments (a premise borne out in California, where water users effectively pay 22% more if their water system is operated publicly rather than privately).

However, there are roadblocks to rapid privatization in the US. For example, private buyers are currently required to make or assume federal debt repayments if the municipality used federal debt to finance the infrastructure. Agreeing on fair market value of facilities is another hurdle. The Internal Revenue Service has introduced some provisions intended to encourage private industry's engagement. Investors still see the terms as largely unfavorable, requiring significant outlays of capital upfront with insufficient returns to recoup investments at reasonable rates (Standard and Poor's, 1998).

In the growing operations and maintenance segment, foreign competition is stiff and increasing. The largest companies include a division of Air & Water Technology, controlled by the giant French water utility, Generale des Eaux; a division of Waste Resources controlled by another huge French water utility; and a division of US Filter. Another French-owned company, Lyonnaise des Eaux, is active in the water utility market and is gearing up for the emerging outsourcing trend in cities across America. US firms are notable for their absence in the overseas water market, dominated by the Europeans.

Solid Waste Management. This segment generated \$39.5 billion in revenues in 1996, making it the second largest segment in the US environmental industry. Of those revenues, the bulk came from municipal solid waste (MSW) business, involving the collection, disposal (through landfills and incineration) and recycling of nonhazardous solid wastes. Roughly \$3 billion was in the area of hazardous solid waste management. Between 1995 and 1996, the MSW segment increased revenues by 4.3%.

Still, analysts forecast that the market does not have great growth potential for several reasons. First, the MSW companies suffer from weak demand resulting from moderate US Gross Domestic Product (GDP) and population growth. Behavior is another key factor. Americans are throwing away less and recycling more trash. Lastly, a number of industries are still trying to recoup bad previous investments (more than \$20 billion) that translated into excess landfill and incinerator capacity (Standard and Poor's, 1998).

In the hazardous waste management (HWM) arena, proposed Environmental Protection Agency (EPA) revisions to Hazardous Waste Identification Rules may reclassify more than 70% of industrial waste from hazardous to nonhazardous. This could drive some hazardous wastes into the MSW market zone, but it could also translate into investments gone bad for HWM companies.

Market growth opportunities in waste management will likely come from consultant services and future development of modified production technologies for industry use that reduce production costs and generate less waste. Over the short-term, an increase in consolidations of businesses and public sector entities in MSW will continue due to extremely high capital investment requirements.

The global marketplace for this segment seems limited, again because of high investment costs, and because of the need for well-developed infrastructure on which to base operations. Consumers must be willing and able to pay for these services – an inhibiting factor in some countries. While the Asian market would seem a logical possibility for US market expansion, many countries (e.g., China) are noteworthy for the absence of strong regulatory and enforcement procedures that would stimulate demand for services and technologies. The recent Asian financial crisis is another drawback to market expansion, at least in the short-term. Europe is a good market target with its highly developed environmental systems and ability to pay for sophisticated US technologies and services. Competition with European companies, however, will be keen.

Air Pollution Control. The air pollution control industry comprises a US domestic market totaling \$12.5 billion in 1996. This segment of the industry includes vehicle emissions control equipment (with \$6 billion in 1996 revenues), industrial emissions control equipment and chemicals (\$5 billion), indoor air control (\$1 billion), and consulting services (\$500 million) (Standard and Poor's, 1998).

EPA's rollback of centralized emissions testing rules and procedures has capped growth in this market. The market's performance will depend on the demand for catalytic converters, which is expected to grow at moderate rates over the next decade assuming current rates in GDP growth. Those manufacturers who invested heavily on the assumption of tighter rules will be living with the consequences of risky investments over the short-term. The health of the US automotive market is another factor affecting market demand in this area. Because of weak economic and regulatory market factors, competition among air pollution emission companies is reported to be intense, and profit margins slim.

On the smokestack front, the market was counting on the federal government's Clean Air Act to stimulate demand. However, US industry's concerns about the high costs in relation to benefits of the legislation have kept a lid on growth in this subsegment, thereby slowing market projections considerably. Little growth is projected through at least 1998, after which some pickup might occur, depending on the administration's ability to gain support for tougher standards and on potential new markets that might surface in implementing global climate change-related treaty agreements.

Environmental Clean-Up (Remediation). Reductions in federal funding, coupled with the Department of Defense's (DoD) progress in cleaning up contaminated military sites, signal a decline in this highly fragmented market. The environmental cleanup industry earned about \$8.3 billion in 1996. DoD remediation peaked in 1994 at \$2.5 billion and is projected to fall to \$1 billion in 1999—showing an average yearly decline of 10% driven by continuing yearly declines in DoD's environmental management budget (Standard and Poor's, 1998). Along with DoD, the other primary government customers are the Department of Energy (DOE) and contracted private industry, including those responsible for Superfund sites, non-Superfund sites, and the redevelopment of "brownfields" (cleaning only to proposed land/facility reuse standards rather than pristine conditions).

The demand in the cleanup market may be shifting from government regulation to internal cost-saving modes, e.g., industries unloading their inventory of contaminated sites. Those industries still conscientiously cleaning up sites are likely to do so through 2000 after which sufficient

progress will have been achieved and the market will become even tighter.

US industries that invested in clean-up capacity are finding that brownfield development is not materializing. Potential brownfield owners appear to be scared off by the remaining unknown risks and liabilities of this relatively new program. Original projections that US industry might play a major role in the cleanup of former Soviet Bloc countries appear to have been overly optimistic, given the generally low levels of US foreign aid available to finance the market.

The Kyoto Protocol and Greenhouse Gases

At the December 1997 Kyoto Conference, 39 countries agreed to binding limits on greenhouse gas emissions to ensure "...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." In particular, the US agreed to reduce its GHG emissions to 7% below its 1990 level. The Japanese agreed to a 6% reduction and the European Union to an 8% reduction below their respective 1990 levels.

While the original targets of US negotiators were 1990 emissions levels, the US gained acceptance of its proposal of *joint implementation* (emissions improvements achieved by multinational firms being credited to the home country), and *emissions credit trading* (less efficient polluters purchase excess pollution allowances from the more efficient). Each of these methods then contributes to reaching national targets.

The 39 signatories to binding emissions limits largely represent the developed world. The rest of the 160 nations attending the conference, including developing nations such as China, India, Mexico, and Brazil did not sign on to the convention's binding targets. Developing countries generally hold that their economic development should not be constrained by pollution restrictions defined by the industrialized nations since industrialized nations were not limited by pollution constraints as they developed and imposing such restrictions now creates a competitive disadvantage for developing countries.

The Chemistry of Kyoto. The six GHGs are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexachloride. These gases absorb infrared energy in the atmosphere, raising the temperature over what would be expected from the naturally occurring mix of these and other gases. Carbon dioxide is responsible for over 60% of this enhanced GHG effect and represents 85% of US GHG emissions.

The combustion of fossil fuels is the major source of carbon dioxide (98.7% of it in the US). Other carbon dioxide sources include cement, lime, and fuel processing. Fossil fuel consumption is spread across utility (mainly power generation) (35%), transportation (31%), industrial (21%), residential (7%), and commercial (5%) sectors.

Clearly, cutting consumption of fossil fuels by the utility and transportation sectors represents a major target of opportunity for GHG emission reductions in the US. The level of emissions of carbon dioxide in 1996 was about 8.9% above the 1990 level used in the Kyoto Protocol, making the 7% reduction below 1990 levels even more difficult to achieve. The next most abundant GHG is methane, which accounted for 10% of the US emissions in 1996. Methane is generated by energy sources (38%), waste management (34%), and agriculture (28%) with major emitters being landfills, agriculture, coal mining, oil and natural gas systems, fossil fuel consumption, and wastewater treatment. Unlike carbon dioxide levels, methane emission levels are falling; they were 2.2% below 1990 levels in 1996.

Fossil fuel consumption is the main emission source for the remaining GHGs. Their levels are an order of magnitude below those of carbon dioxide and methane.

CHALLENGES

The environmental industry faces many challenges, such as global warming, regulatory structure, establishing and enforcing standards, and penetrating global markets.

Global Warming

A combined effort by industry, the American public, and government will be needed to get global warming under control. The challenges are wide-ranging—increased efficiencies through process changes and better technologies, development of renewable energy sources, and more effective government leadership. Promising technologies already exist. For example, the automobile and petroleum industries are major contributors to global warming. One-third of carbon dioxide emissions come from automobiles, and aggressive efforts are already underway to attack the problem. Reduced vehicle weight and smaller, hybrid, and completely electric engines all hold great promise. Alternative fuels and fuel cell technology research continue to make progress.

Regulatory Structure

The US environmental regulatory structure can best be characterized as a command-and-control system, regulation based, litigation driven, often inflexibly pegged on what *was* a best available technology at some point. For example, a California environmental firm had a scientifically sound new technology that could only be sold to the regulatory community when it was creatively packaged as just another form of existing (and approved) pump-and-treat methods. The test-measurement approach to regulation developed during the US environmental movement over the last 30 years. In large measure it was appropriate as America learned to be environmentally responsible and focused mainly on remediation.

However, conditions have changed. Technology is generating new and better solutions with increasing rapidity. The focus, nationally and internationally, is increasingly on pollution prevention. The US has a large and diverse environmental industry and other industries that (by law) have to be environmentally conscious.

If the US is to have the agility to compete in world markets, its environmental regulatory structure needs to create incentives for industry to take risks in improving efficiency and going beyond compliance. The days when a best technology at some point in time could be blindly adhered to as the only possible standard are gone. Without a change, US industry will find itself sorely pressed to compete with firms overseas whose governments are highly cooperative in setting standards and embracing new technologies.

Standards

Individual countries have their own standards and enforcement systems. In 1992, the International Organization for Standardization began the promulgation of a system of environmental standards, the ISO 14000 series. The capstone standard is ISO 14001, an overarching environmental management system (EMS) standard. It is a voluntary, process-oriented system standard, not a performance standard. As a system standard, it does not go so far as to establish best practices.

The major issue surrounding ISO 14001 is whether or not it will be a useful tool, and where and when it might become a condition of market entry. Many global (and US) companies have EMSs in place, that in many cases are more advanced than ISO 14001. Although some US companies have moved forward to become ISO 14001 certified, many have adopted a wait-and-see attitude. Certification of individual facilities

or corporations can cost hundreds of thousands of dollars. ISO 14001's value will ultimately be determined when issues such as supplier certification and the relationship of ISO 14001 to national standards are resolved and there is pressure on individual national standards bodies to certify firms to provide advantages in market entry. Right now, many US companies are adopting useful parts of ISO 14001 and positioning themselves to be certified if necessary. The decision will depend largely on customer nations making certification a condition of market entry. There seems to be more enthusiasm in Asia and Europe for the ISO 14000 series than in the US. This may be due to the strong command-and-control nature of the US regulatory landscape and the more cooperative approach (between government and industry) other nations have taken. Europe has been a leader in ISO 14000 development as an offshoot of EU standardization (US-Asia Environmental Partnership, 1997).

Market Penetration of the Industrialized World

The most significant feature of the US environmental industry's penetration of the industrialized world's markets is that we are not trying hard enough. It seems that most federal programs for marketing US technology and services overseas are focused on the developing world because it represents the markets of the future. In doing that, we are missing the markets of today—the developed world.

Europe is the world's biggest environmental market after the US. Throughout Europe, we see: great environmental awareness and willingness to pay for environmental stewardship; a respect for technology; good industry-government relations that have developed a forward-looking incentives-based regulatory system; and the ability to pay for sophisticated environmental technologies and processes. Yet this seems to be a market we have chosen largely to ignore.

This is not to say that penetrating European markets will be easy. In Russia and Central Europe, nothing will happen without financing as part of the deal. The European Union treats the environment as a strategic industry; the environmental industry in Europe is far less fragmented than that in the US. It seems, however, that a program resembling US-AEP for Europe would more than pay for itself.

OUTLOOK

Impacts of Kyoto

US business and industry have strong reservations with the Kyoto Protocol commitments, pointing to potential constraints on US economic growth. Estimates from business and industry project as much as a 3% decline in GDP, and a potential loss of about 2.5 million new jobs by 2010, as well as a reduction in annual household income of \$2,000 (O'Keefe, 1998). Other claims (Antonelli and Schaefer, 1997) include electricity price increases of 40-50%; 20-30% loss of chemical industry to developing countries; 30% decline in steel production; domestic paper production decline; closing of all primary aluminum smelters by 2010; 20% reduction of petroleum refining output; and closing of 23-35% of cement industry.

Many industries regard the international emissions trading and joint implementation provisions of the Protocol too difficult to reach agreement on to meet the 2008-2012 reductions timetable. They argue that without global participation, there is little environmental benefit to pursuing the reductions, especially in view of projected growth in the economies of the developing countries, which will contribute the most to future emissions. US industry senses that too few technology-induced products will be on line in the requisite amounts by the year 2010 to meet Kyoto targets.

While this worst-case scenario of the impacts from the US commitment to reduce GHG emissions paints a grim picture, there are more positive estimates about technology deployment prospects. A consortium of five DOE laboratories conducted a study regarding the potential for energy-efficient and low-carbon technologies to reduce carbon emissions in the US. The report makes a strong case for the value of energy technology research, development, demonstration and diffusion in response to global climate change (DOE Laboratory Directors, 1997, 1.1). It considers four key sectors of the US economy (buildings, transportation, industry, and electric utilities) and proposes large increases in R&D targeted at emissions reductions and national emissions credit trading schemes. The study's various scenarios achieve 30%-70% of the emissions reductions needed to meet Kyoto goals. The report concludes:

- A vigorous national commitment fueled by a massive influx of financing for research and development could reverse the trends of increasing carbon emissions by 2010.

- The energy savings attained are roughly equal to or greater than the costs if feasible ways are found to implement the carbon reductions.
- The next generation of energy-efficient and low-carbon technologies promises a continuation of carbon reductions over the next 25 years.

This picture is markedly different from the industry view. The study results are predicated on increased R&D funding; successful market response to emissions trading; and continuing technological improvements in carbon reduction technologies. Realistic expectations probably lie somewhere between the extreme pictures painted by business and industry and the DOE study.

Mobilizing Technology

Power generation, particularly through coal-fired power plants (the source of most of our power) is a major contributor to carbon dioxide emissions. The use of low sulfur coal has helped. Some potential exists for emissions reductions merely through efficiency and price increases (DOE Laboratory Directors, 1997). Nevertheless, the use of electricity will continue to grow in the US and abroad. America's rejection of nuclear power might need to be revisited. The absence of nuclear power puts even greater pressure on developing new clean-coal technologies. There is some innovative work being done to produce clean fuels out of coal. For example, ARCTECH Inc., a small, private research firm near Washington, DC, is developing a coal bioconversion technology that converts coal into fuel gas by using microorganisms. This process can potentially generate over 80% of the heat the coal would have produced, while greatly reducing carbon dioxide emissions and producing an effective fertilizer from the waste product.

Renewable energy sources like biomass (using wood, agriculture, municipal waste, and landfill gases as the energy source), geothermal, hydropower, photovoltaics, solar thermal, and wind are expensive, but research is continuing to make them more economically attractive.

Natural gas is a promising option in the short-term, considering the increasing reserves found in the US and Canada. Natural gas generates 99% less sulfur dioxide, 81% less nitrogen oxide, 58% less carbon dioxide, 96% less particulates, and 100% less solid waste than clean coal (Bradley, 1997).

There are many simple technologies for home and office use to conserve energy and thus reduce GHG emissions. From the many

energy savings appliances on the market, to the alternative ways to produce heat and hot water (solar and geothermal), these technologies do have higher up-front costs but result in lower operating costs. For instance, manufacturers are producing energy-efficient lights. Likewise, low-emission window coatings that are transparent to light and reduce heat loss save \$1.8 billion per year. Also, better insulation is an inexpensive technology to improve heat and air conditioning efficiency.

DOE has labored to show businesses how energy efficiency and pollution prevention have benefits in terms of cost savings, safer working conditions, regulatory compliance, improved performance, employee morale, reduced liability, and positive community relations (US Dept. of Energy, 1997a). For example, Coors has reduced toxic emissions by 90% through improved packaging, alternative fuels, and improved production processes. The Dow Chemical Company is working with DOE and is demonstrating technologies such as dry nitrous oxide combustors or low nitrous oxide burners for boilers and furnaces. Dow has reduced its emissions by 51%. Dupont is eliminating nitrous oxide emissions by destroying or recapturing them for beneficial use.

Research and Development (R&D)

A wide range of environmental technologies is available, but more need to be deployed if we are to reach Kyoto limits. The environmental technology industry remains fragmented, and much disagreement remains on its proper course and role. There is no clear roadmap to meeting the Kyoto requirements. As noted above, government and industry are already working together in some cases to develop and implement energy-saving technologies. More cooperation is necessary to work out the tough issues of bringing promising technologies to market, particularly from the government side. Financing, consumer and industry awareness, the potential for duplication of effort, and the need for complementary public-private research calls for more coordination at the national level.

GOVERNMENT GOALS AND ROLE

Clinton Administration Goals and Initiatives

The US Climate Change Action Plan, announced in October 1993, was the Clinton administration's attempt to begin to address global warming in a serious manner. It stresses five goals: preserving the environment; enhancing sustainable economic and environmental

growth; building partnerships; encouraging international emission reductions and cooperation; and involving the public.

Specifically, the US strategy for implementing its Kyoto commitments (*1997 Submission of the US*, 24) embraces both domestic and international measures, including increasing the efficiency of power generation and use; adopting renewable energy technologies; reducing air pollution; improving agricultural and livestock practices; decreasing deforestation and improving land use; facilitating the commercial transfer of energy efficient; and renewable energy technologies that can help developing countries.

President Clinton's January 31, 1998 radio address to the nation proposed a number of initiatives focused on global warming. The comprehensive plan aims to reduce emissions while stimulating economic growth. It includes a \$6.3 billion package of tax cuts and new spending; a \$3,000 tax credit for anyone who buys one of the new advanced-technology cars, and \$4,000 when they become more efficient; and tax credits up to \$2,000 for energy-saving water heaters, air conditioners, solar panels, and energy-efficient homes.

New spending would support more research on energy efficiency and renewable energy aimed at realizing up to a 30% reduction in energy consumption by 2010. Additionally, two administration initiatives with the industrial sectors of the economy are planned. One would restructure the electrical power and utility industry to bring about greater competition, lower prices for consumers, and reduced emissions. Another would develop industry-specific partnerships aimed at devising strategies relevant to that industry for reducing emissions. One of the most promising features of this particular effort is the careful examination of the so-called technology pipeline, an attempt to streamline the technology process in light of the variety of engineering, financial, and legal obstacles that are slowing development.

Assessing the Administration's Proposals

Any strategy designed to reduce emissions to meet Kyoto targets is faced with huge challenges. First, how willing will the federal government (and political system) be to resource the effort? For example, we really do not know how much new R&D will be needed to deploy an adequate stream of sufficiently advanced emission reduction products to market. Second, real success will come only when industry embraces Kyoto-focused emissions reductions. Industry will be more willing to do that when it sees the money for R&D, and when it has incentives to take risk, especially when considering the cost of reducing

emissions against their financial bottom line. Industry will want to sense a change in the regulatory structure away from fixed standards and punitive control to a system that recognizes new technologies and that rewards going beyond compliance.

All of this takes resources at a time when the economy is booming. However, according to some industry leaders, government today is not aggressive in enforcing existing environmental regulations for fear of slowing the boom.

To the Clinton administration's credit, its current proposals hone in on the high-payoff targets of carbon dioxide and methane, and are steps in the right direction. However, given the actions taken to date, our ability to reduce emissions sufficiently to meet the targets by the 2012 deadline is questionable. Much more must be done to set the conditions to encourage and support corporate success and to marshal public support.

An Enhanced Government Role

Technology is only one part of the answer to Kyoto and other environmental challenges. Money and other resources, as well as the regulatory structure, must also be mobilized. Most of all, someone needs to be in charge. Right now, the US environmental effort is fragmented. The EPA promulgates very restrictive regulations but largely leaves it to the states to enforce. National laboratories are doing great R&D but are inexperienced at transforming basic research into marketable products. US companies have spent large amounts of money trying to be good corporate citizens by implementing pollution reduction and prevention controls on their own. Despite the large number of councils, foundations, and firms, there seems to be no central clearinghouse for information, coordination or direction. Finding new technologies and processes is very much an act of individual discovery. This is perhaps not surprising in a fragmented industry consisting of diverse giants and small niche companies. No effective trade organization has developed as in other industries.

The time has come for the federal government to reinvigorate the process, starting with a new role for itself. First, a national plan with congressional support to harness ideas and create incentives for action is needed. The Clinton administration initiatives outlined in *Technology for a Sustainable Future*, the 1998 State of the Union proposals, and the CCAP are steps in the right direction. Next, regulatory reforms with pollution prevention emphasis are needed that encourage innovation, reward risk and progress, and remove barriers. Finally, accelerated and

increased support for research and development, along with new strategies and mechanisms for penetration into the global marketplace, are essential.

The International Scene

As previously mentioned, the environmental industry resides in an increasingly international venue. Pollution does not recognize international boundaries. Frameworks like the Kyoto Protocol bind environmental, economic, sovereignty and national security issues tightly together. US environmental businesses, in order to grow, must find a larger share of their markets overseas either through expansion with their corporate clients or by identifying new market opportunities. This creates an imperative for greater attention to the global marketplace—to the growing importance of international standards, in particular, and no less to the differing business climates in the developing and developed worlds.

The Developing World. Developing countries are faced with a tough dilemma — how to expand their economies through their industrial age without sacrificing the environment. Some would argue that the industrialized world got a free ride polluting its way through industrialization to the point where healthy, mature economies could then begin to address the environmental mess left behind. India, for example, has an economy about to takeoff, increasingly threatening environmental problems, and a population that is projected to exceed China's by 2037. What does India do? Should it maximize economic growth in order to continue feeding itself and providing a decent standard of living for its people? Should it accept less for its people by diverting part of its growth toward environmental stewardship? Also, consider that the two options are not mutually exclusive because of the hidden health, safety, and productivity costs borne by the rapidly growing society that chooses to neglect the environment for now.

If this is the type of market that US companies must penetrate—one where a local partner is required for entry into the market and where locals prefer just to get the technology without the expense that comes with a US firm—how should the US proceed? It is increasingly clear that if US firms do not present a complete business package that includes financing (including grants), they will lose out to Japanese or European firms whose governments are willing to underwrite projects in many different ways.

Security interests are never far away from environmental issues. For example, Asia relies twice as much on coal for power generation as the

rest of the world. Growing populations and economies demand more electrical power, which translates into greater pollution that slips across borders in the form of acid rain. As the developing world grows and demands more oil, it may seek lower sulfur-content oil to lessen environmental problems, thereby focusing demand away from the Middle East toward Kazakhstan and Russia. Such developments, by their nature, will raise concerns about sovereignty and assured access to vital resources.

US clean-coal technology, solid waste management practices, and other products and processes are marketable items that can contribute to the health of the US economy and to development and stability in other parts of the world. Continued efforts like the US-Asia Environmental Partnership (US-AEP), where US products and services are marketed and integrated overseas are a must. More importantly, the US government needs to address the unequal playing field of international financing. A reassessment of US foreign aid, grant schemes, trade agreements, and private financing instruments is critical to ensure that US companies can compete with firms from Japan and Europe. The group does not recommend one tool over another but merely observe that there does not appear to be a coherent approach to helping US firms compete overseas.

Key International Issues. In both the developed and developing worlds, agreement on joint implementation and emissions trading schemes is critical if anything is ever to come of Kyoto. The US and the other industrialized nations will be extremely hard pressed to meet Kyoto emissions goals by going it alone — relying only on what we do inside our respective borders. The increasingly interconnected global economy is a pressure-relief valve where US companies can help developing countries improve their environment and at the same time bring home to the US credits that could not otherwise be achieved without huge costs to the domestic economy. Likewise, trading emissions credits between countries will add efficiency to the Kyoto process.

It makes sense for the US to leverage technology in solving its own environmental problems and in attempting to penetrate world markets. After all, we are the global leader in environmental technology in many areas. Technology drives standards, and so we can and should take the lead in developing international standards rather than being forced to react to the rest of the world's agenda.

The Clinton administration's commitment to engagement needs to find its way into environmental issues in substantial ways, both domestically and in harmony with the actions of other nations around the globe. The US environmental industry is unlikely to embrace totally Kyoto or aggressively seek overseas markets if it does not see its

government engaging the rest of the world on all fronts. Environmental changes depend on economic changes —hidden benefits have to become visible benefits.

CONCLUSION

The US environmental industry is a unique sector in transition. American competitiveness and multilateral cooperation among developed and developing countries will be key issues over the coming decades. The challenge for US industry is to become better integrated globally — an aim that would not only serve Kyoto goals, but speed the transition away from a stagnant domestic market. The US command-and-control approach to environmental protection has resulted in an extensive regulatory framework with adversarial relationships between government and business, conflict resolution through litigation, and little incentive for business to go beyond minimum compliance. Federal and state governments must develop a coherent regulatory and incentive framework that preserves the environment, a rising standard of living, and domestic and international opportunities for US industry.

Human activity continues to have a discernible impact on the global climate by releasing greenhouse gases that trap heat in the earth's atmosphere. The United Nations Framework Convention on Climate Change is one enabling mechanism for dealing with the problem. Nations are beginning to adopt policies and implement measures to limit greenhouse gas emissions and to protect greenhouse gas sinks.

Technology provides some of the tools the world will need to combat global warming. Zero-emission vehicles, cleaner and more efficient power generation, and advances in insulation and building design are available now and continue to improve. Markets for these technologies are rapidly expanding as the world discovers that technological solutions can not only solve ecological problems but also provide low-cost advantages for businesses and long-term savings for end users.

However, advanced technologies are not the complete solution. In the US and the developing world, behavior modification is critical. We face tough choices in eliminating or reducing carbon dioxide emissions from our transportation and industrial sectors. Complex issues such as removing energy subsidies, subsidizing the purchase of electric cars, and reengineering the layout of our cities and suburbs lie ahead. Most of all, we will need educated citizens and enterprises that understand the problem of global warming and acknowledge their roles in the solutions.

Domestic and international problem areas cry out, "show me the money." Domestically, individuals and industry need to be offered

incentives developed in partnership with government, and bolstered by a reformed regulatory system and greater technology development. Overseas, potential customers look for money as part of a complete package that includes concessionary project financing, technology transfer, joint implementation investment, and emissions trading mechanisms — a strong argument for US government and industry collaboration, particularly in the development and adoption of international standards.

Global warming, the health of the environment, and improvement of the competitive posture of US environmental industries are not insurmountable problems. Like most challenges, they involve cost-benefit tradeoffs. The greatest risk lies in our doing nothing —because the global temperature will continue to rise, and our competitors haven't indicated that they will stop fighting for markets or developing more advanced technologies. Taking care of the environment, once largely a social imperative, is now an economic necessity, a necessity that demands US leadership.

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HEALTH CARE

ABSTRACT

The structure of the health care industry has remained unchanged for five years, so an assessment of the health care industry would change only incrementally from that of previous years. Thus, this nontraditional study report presents several issues of concern to the group: rights of patients; implications of "Buy America;" the Medicaid program; malpractice; and euthanasia and assisted suicide. Next, the report presents five essays on major elements of the health care industry: cost containment, medical research, military medical forces in the 21st century, ethics of health care delivery, and alternative medicine.

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Cook County Hospital, Chicago, IL
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George Washington University Medical Center, Washington, DC
National Naval Medical Center, Bethesda, MD
Siemens Gammasonnics, Chicago, IL
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INTRODUCTION

It may be argued that Americans benefit from the best health care system in the world. The industry consists of public, private, and nonprofit organizations that deliver health care and companies that provide pharmaceuticals, equipment and devices, and administrative services.

As a market-based system, the US health care system generates approximately \$1.039 trillion per year of economic activity or 13% of the Gross Domestic Product (GDP). The per capita expenditure on health care in the US is \$3,760. In 1998, the health care costs were projected to rise by 5.9%, compared to a 5.6% increase in 1997. These figures highlight the American health care system as the most expensive in the world. The high costs associated with the system are generating fierce competition for available private and public resources (DRI/McGraw-Hill, Standard & Poors, and US Department of Commerce, 1998, p. 45-2).

Although the general US economy is robust, factors will intensify cost containment pressure on the health care industry. A growing gap exists between the rich and poor. This will result in increased pressure on Medicaid resources and increased public costs to cover emergency care for the uninsured. Additionally, an ever-increasing population of senior citizens may stretch the Medicare budget beyond its limit.

As efforts are made to decrease the cost of health care and as the competition for available resources intensifies, tough decisions are required by insurance companies, hospital administrators, and health care professionals. Ultimately this could lead to an uneven distribution of health care and could leave many Americans without coverage. In addition, the quality of care provided could decline. On the other hand, advances in medicine and biotechnology will continue to support the discovery and production of new pharmaceuticals, safer and more effective vaccines and faster and more reliable diagnostic tests.

In short, the challenges associated with patient expectations, new and expensive technologies, a growing elderly population, and the pressure to contain costs will continue to strain our health care system. This health care study group has spent considerable time and effort examining these and other challenges faced by the industry. The following is an examination of the controversial issues facing the industry.

ISSUES

The health care industry is growing dramatically as a proportionate share of the GDP, though it has produced extraordinary results for the trillion dollars spent annually. Advances in diagnostic procedures and treatment of all known maladies have been remarkable. The future holds even greater promise with the coming of telemedicine, less invasive treatments, and the potential of biotechnological care. However, the industry faces many challenges: an increasing emphasis on patients' rights; federal intervention in support of "Buy America"; the burden of the Medicaid program; escalating malpractice litigation against medical practitioners and institutions; and euthanasia and assisted suicide.

Patients' Rights. In 1997, President Clinton created the Advisory Commission on Consumer Protection and Quality in the Health Care Industry. This commission's purpose was to recommend measures to promote and assure quality health care and value and to protect consumers and workers in the health care system. The President asked the commission to develop a "Consumer Bill of Rights" in health care and to provide him with recommendations to enforce those rights at the federal, state, and local level. The President accepted the commission's recommendations outlined in its report "Quality First: Better Health Care for All Americans."

The President challenged all private health plans to adopt the commission's consumer bill of rights and he challenged Congress to pass federal protections into law. He also directed every federal agency that administers or manages health plans to adopt the protections of the bill of rights, and recommended the creation of a permanent Health Care Quality Council to set new goals and track progress in meeting those goals.

The impact of the commission's report is unclear. If supported by legislation and implementing regulations, the impact would be significant. Otherwise, minimal impact is likely.

Federal Intervention in Support of "Buy America." The Berry Amendment restricts the Department of Defense (DoD) from buying clothing and fabrics not grown or produced in the US, Puerto Rico, or its possessions. Some senior members of Congress, supported by the American Textile Industry, believe that the US needs the Berry Amendment to protect American jobs. Commercial products such as bandages, gauze, sponges, and medical clothing are subject to this amendment. The Defense Supply Center-Philadelphia (DSCP), DoD's major buyer of medical/surgical products with sales over \$1 billion annually, implements this Buy American restriction.

A recent study of more than 160 medical and surgical suppliers revealed several concerns about the Berry Amendment. These suppliers do not have a mechanism for ensuring or certifying that subcontracted vendors comply with the amendment. Further, DoD represents less than 5% of the medical and surgical suppliers' market, so they don't have an incentive to change their business practices to accommodate the restrictions. Therefore, suppliers are offering less than their full line of products to DoD (only those they can certify as domestically produced). Yet, despite DoD restrictions, manufacturers are seeking global outlets for their products, suppliers, resources, technology, and production factories to meet their other consumer demands.

The Berry Amendment restriction on DoD purchases has had little measurable impact on the domestic industry. The amendment does nothing to boost our industrial base — the US textile and apparel industry is able to supply DoD's requirements. The amendment has had the greatest negative impact on DoD, specifically, DSCP. DSCP will inevitably face a reduced pool of suppliers, thus, reducing competition and resulting in potential requirements to pay higher prices for otherwise available products.

Congress should stop fighting for Buy American restrictions. The study group's findings support the immediate repeal of the Berry Amendment. In a global marketplace, protectionism hurts US industry because it stifles its incentive to modernize and become competitive. Instead, let us send the right message to other nations —one that encourages them to open their markets to us.

Burden of Medicaid. Medicaid health care is big business; it is expensive, and it is growing. It accounts for approximately 6% of the federal budget and 10% of federal entitlement spending. At the state level, Medicaid spending made up 13.3% of state "general fund" outlays (raised from taxes not earmarked for specific purposes). This ranks second behind elementary and secondary education at 33.8%. In 1994, Medicaid surpassed higher education as a proportion of state general fund spending.

Since the program was legislated in 1965, Medicaid outlays rose over 8,000% (see Table 1).

Table 1: Medicaid Outlays (Amount in Billions of Dollars)

Year	1967	1968	1995	1996
Amount	1.9	3.3	155.0	160.0

Medicaid payment growth rate is also staggering. Between 1984 and 1994, combined federal and state Medicaid spending quadrupled from \$36.7 billion to \$135.5 billion. Between 1990 and 1992, spending increased 9.8% probably due to an increase in Medicaid managed care enrollment. The projected growth rate is expected to remain at 10% through the year 2002, significantly outpacing the rate of inflation. Table 2 reflects the number of Medicaid recipients and trends from 1975 to 1997.

**Table 2: Health Care Financing Administration (HCFA)
Statistics: Populations (in millions)**

	<i>Fiscal Year</i>					
	1975	1980	1985	1995	1996	1997*
Populations	<i>In Millions</i>					
TOTAL	22.0	21.6	21.8	36.2	37.5	38.7
Age 65 and over	3.6	3.4	3.1	4.2	4.4	4.6
Disabled	2.4	2.8	2.9	5.9	6.2	6.5
Dependent children <21 yrs	9.6	9.3	9.8	17.6	18.2	18.7
Adults with dependent children	4.5	4.9	5.5	7.8	8.0	8.3
Other Title XIX	1.8	1.5	1.2	0.6	0.6	0.6

*1997 figures were estimated. Source: "HCFA Statistics: Populations," 1996

Medicaid recipients account for 14% of the US population. The number of recipients increased by 60% between 1975 and 1996, with a projected average annual growth of 2.7%, reaching 43 million by the year 2002.

Cost Maintenance Pressures and Litigation. Why must we expend so much of our health care money on malpractice insurance, lawyers, courts and settlements? Is there a better way to protect the innocent and avoid incompetence? The system appears to be motivated more by greed than by trying to provide high quality care for the least cost. We can improve

the current malpractice system in the US health care industry by looking at the players and their motives to find a way to meet their needs.

A system like ours that looks for winners and losers is in trouble. This system sometimes tries to resolve the unresolvable. Not every death is a wrongful one. No doctor is perfect. Blame is not always assignable. In other words, this is not a perfect world and sometimes "bad stuff" just happens. Let us modify our adversarial system so that it continues to protect the innocent within reasonable bounds.

To do this, we must figure out how to balance the needs of the many against the needs of the few, without allowing the many to trample on the rights of the few. We need safeguards. Our founding fathers understood this principle, although not immediately. After they completed the Constitution, they developed the Bill of Rights, a list of protections to avoid abuses of power by the majority. Why not apply a similar solution to this problem—a Healthcare Malpractice Bill of Rights? It sounds simple but it would be difficult to implement given the entrenched special interests involved. Nonetheless, if we do not try to simplify the current system, the cost of malpractice litigation will continue to divert funds from the primary focus of the health care industry—helping patients.

Euthanasia and Assisted Suicide. In 1994, voters in Oregon approved, although narrowly, an initiative that would allow a terminally ill adult to obtain a prescription for a drug dosage that would end that adult's life. The first act of its kind anywhere in the US, the Oregon Death with Dignity Act addresses an issue that fuels emotions and generates contentious debate on the constitutional aspects of the practice of euthanasia. During the past decade, it has been apparent that religious and ethical convictions sharply divide Americans about assisted suicide on moral and constitutional grounds. As the 21st century approaches, the issue will remain significant legally, politically, and morally.

ESSAYS

This section presents five essays on significant issues affecting the health care industry.

Essay 1: *Cost Containment: Fantasy or Reality?*
(COL Joe Carstens, USA)

Although rising health care costs have been a concern for years, individuals and patients, employers, and the government suffered in relative silence. It wasn't until the 1992 presidential campaign that everyone expressed their frustration and concern over this growth in costs and the significance of these costs. This paper will explore proposals for containing these rising costs.

America's love affair with health care blossomed as the industry "eliminated" polio, diphtheria, measles, and whooping cough. As the industry responded to America's demands for care, a unique market structure developed—market competition was rejected and professional dominance enshrined. In this professional model, fiduciary responsibility resided with the provider not the patient. The model assumed the primary focus was on positive medical outcomes whatever the cost (Altman and Reinhardt, p. 236).

Although efforts were made to control costs in the 1970s and 1980s, they were unsuccessful. Thus the government, through Medicare, focused on provider payments as the solution. The government instituted a payment system based on predetermined, fixed Diagnosis-Related Groups for hospitals and a resource-based fee schedule for physicians. Hospitals were paid a standard rate based on the problem's complexity and physicians were encouraged to focus on medical evaluations vice expensive procedures (Altman and Reinhardt, pp. 17-18). Unfortunately, these efforts were shortsighted as they addressed Medicare enrollees instead of the entire population and they failed to change patient/provider decisions.

As a result, costs continued to rise. According to Altman and Reinhardt (p. xxiv), by "the 1980's, it had become clear that the level at which health care spending was projected was not sustainable. And if the historical differential of three percentage points between the annual growth rate of health care spending and the growth in the rest of the GDP continued unabated into the twenty-first century, the nation would be spending over half of its GDP on health care by 2050." Additionally, "... no other industrialized nation spent anywhere close to as much on health

care as did the United States..." (Altman and Reinhardt, p. xxiv). Further analysis revealed that American companies were forced to "raise prices of goods and services, making them less competitive here and overseas" (Potter and Youngman, pp. 398-399). American companies also reported that their health care bill grew from \$74 billion in 1986 to \$225 billion in 1991, which equaled 29.9% of the nation's health care bill (Potter and Youngman, p. 382). In 1990, a 30-minute wait for each of the 704 million physicians visits cost American businesses \$3.5 billion in productivity (Herzlinger, p. 25).

Health care costs remained immune to controls because basic economic principles were ignored. The professional model precluded any reduction in costs. In the model, neither the provider nor the patient is threatened by the cost of the service. The provider focuses on positive clinical outcomes and prescribes multiple tests, refers the patient to a specialist, and/or hospitalizes the patient. The patient knows that a third party will pay, so is unconcerned about cost or number of services provided. Altman and Reinhardt argue that, "...whether payment is made by the government or by a private insurance company, individual patients pay a price far lower than the cost of the service, and, as a result they attempt to use almost unlimited amounts of care (p. 2). They also state that third party financing "...substantially increases the ability of consumers to pay for more...care" and providers add new services because they know that patients face few financial constraints since the third parties pay the bill (Altman and Reinhardt, pp. 12-13).

Costs will not decrease until the professional model gives way to market competition. Dr. Herzlinger believes that "... the market and only the market can provide health care that the American people want at a price they are willing to pay." (Herzlinger, p. ix). The industry is already responding to market pressures as evidenced by the growth of Health Maintenance Organizations (HMOs). One survey of 2,000 public and private employees found that HMO membership had grown from 29% in 1988 to 51% in 1993 (Altman and Reinhardt, p. 109). Another study found the number of HMOs had grown from 175 with 6 million enrollees in 1976 to 550 with 51 million enrollees in 1996 (Altman and Reinhardt, p. 209). This growth has challenged the supremacy of the professional model. HMOs offer government, employers, and individuals services and costs that traditional providers refused to offer or were unable to offer. HMOs provide convenience and capitated rates for identified services. Additionally, capitated payments "...create incentives to keep enrollees as healthy as possible and, when illness strikes, to restore the patient's health as cost effectively as possible" (Altman and Reinhardt, p.116). Although not all of the data is in, it

appears that for now, HMOs have arrested the growth in health care costs. This was achieved by reducing hospital admissions, the length of hospital stays, the number of tests; and by denying marginal medical procedures.

The growth and popularity of HMOs reflect the growth of market competition in the industry. Traditional providers have lost the business and revenues of 51 million Americans. Physicians are giving up individual practices and forming large multispecialty practices that provide patients a wide range of services and specialties. Physician groups are buying hospitals and offering fully integrated delivery systems (IDS). Similarly, hospitals are buying other hospitals and physician practices as they offer their own IDS to protect their revenue stream. They are also eliminating excess capacity as measured by bed availability and the ancillary support for those beds. All these efforts by traditional providers are "...directed toward finding partners and developing arrangements that enable providers to bid on managed care contracts" (Johnson, Brown, and Johnson, pp. 10-11).

While many in the industry welcome competition, the accomplishments to date are only the first step in controlling costs. To date, changes have resulted in the creation and growth of HMOs; reduction in costs and in individual practices, specialists, and hospitals; consolidation of traditional providers horizontally and vertically; growth of primary care physicians; limited choices; and denial of marginal services.

Although the paradigm has changed, the consumer has yet to substantially benefit. The HMO challenge forced traditional providers to change. While the changes benefit the consumer in some ways, the primary purpose is to protect revenue streams. This competition reduced margins for HMOs and traditional providers and generated reductions in the industry's costs. Unfortunately, these reductions have "little positive meaning for the consumer [as] providers do not usually pass on...savings to consumers." (Johnson, Brown, and Johnson, p. 29). "A 1994 research report found that hospitals continued to compete on the basis of service, not price. (Herzlinger, p. 227). As providers compete, they look for ways to reduce their costs and to protect or increase revenue streams, not for ways to reduce consumer costs.

More competition is required if the consumer is to see lower costs. As the industry seeks equilibrium, the HMO/traditional provider battle over market share will promote innovation. This market-inspired innovation will be the change agent for lowering costs. Dr. Herzlinger (p. 158) writes that focused factories are the wave of the future for lowering costs. She finds the "health care industry filled with

opportunities ... ranging from [factories] that perform only one procedure, like cataract surgery, to those that provide the full panoply of care for a disease like cancer.” Two segments, eyewear and some components of the dental segment, have adopted this philosophy. A study of the eyewear sector found that prices for eyewear services were 25 to 40% lower in those states that allowed focused factories such as Pearle Vision to operate (Herzlinger, p. 35).

These factories will be a result of the industry shakedown that is occurring. They will capitalize on best business practices: location, extended hours, volume, and quality. So far, focused factories provide a quality of service that traditional providers cannot achieve. Many factors contribute to the high quality service: a single focus on a procedure or a disease, high volume, repetition, ancillary services to support the procedure or illness, and a medical staff with shared experiences.

An environmental scan showed that everyone is looking for new ways to do business in the 21st century. Yet, new ways are threatening and potentially wrong. The industry is wary of change so traditional providers lean toward marginal changes, such as repackaging delivery systems to compete with HMOs. On the other hand, focused factories completely restructure its services to provide consumers choices, information, convenience, higher quality, and lower costs. Usually, focused factories provide the best solution for lowering costs without sacrificing quality.

Essay 2: Medical Research (Gregory Doyle, Dept. of the Army)

At a recent symposium, Senator Tom Harkin (D-Iowa) stated: “The federal government should find new ways to raise money for biomedical research, rather than cut health programs to pay for growing research efforts” (Muller, 1997). Investment in biomedical research is widely viewed as an investment in the future, and a proactive means of reducing the health care expense by finding ways to prevent and cure diseases.

Americans spend an estimated \$90 billion a year treating Alzheimer’s disease; while the government provides about \$300 million for related research (Muller, 1997). Similar comparisons can be made for diabetes, mental illness, and other debilitating conditions. If more money were invested in basic and advanced research, the ultimate price of treatment would be significantly reduced. Many believe that sustained growth in medical research funding is needed to build upon past scientific achievements, to address present medical needs, and to anticipate future health challenges.

Public Investment. The Clinton administration strongly backs biomedical research investments. Since 1993, the National Institutes for Health (NIH) budget has increased by 23% (National Institutes for Health). For fiscal year 1999, President Clinton has proposed an 8.1% increase in the NIH budget, with increases through fiscal year 20003 totaling 33% after inflation (American Association for Advancement of Science). Similar increases are being sought for the research efforts of the National Cancer Institute, the Human Genome Research Institute, and the Health Care Financing Administration. (Cordes, p. A38). Many believe these increases are not enough. The Ad Hoc Group for Medical Research Funding, a leading interest group, has called for a national commitment to double the NIH budget over the next five years (Ad Hoc Group, p.1).

These budget increases are not a certainty. The Senate Budget Committee recently approved their own fiscal year 1999 plan, which rejects most of the President's initiatives for expanding research expenditures (Edsall and Planin, p. A1). Clearly, the federal budget is a political statement as much as a reflection of the public's needs or desires.

Private Investment. While the federal government is the primary source for basic health care research funding, there is a significant research investment by private enterprises, particularly in applied and developmental research. As a group, medical products and services firms contribute an estimated 7 to 8% of their annual revenues to R&D, versus a national average of 3 to 4% for all US manufacturers.

Major drug manufacturers exhibit an even greater propensity to invest in R&D; over the past two decades, R&D expenditures have risen sharply. Indeed, the drug industry is one of the most research-oriented sectors of the US economy. Its total R&D outlays are expected to equal more than 21% of total industry revenues for 1997, compared with 15.9% percent in 1990 and 11.7% in 1980 (Standard & Poors Industry Survey, p. 16).

The Future of Biomedical Research. The future of biomedical research is a matter of extensive public policy debate. One needs only recall the highly charged atmosphere that characterized the initial federal entry into HIV/AIDS research. Federal investment decisions reflect the scope of health risks faced by the population. Additionally, special interest politics is increasingly influencing research investment decisions.

A significant factor affecting health care investments in the near future will be the major shift in the age distribution of the US population. This shift will increase the prevalence of diseases and conditions associated primarily with the elderly, such as some types of cancer, brain

dementia, frailty, osteoporosis, and many types of disability. Many researchers are likely to study ways of ameliorating the terrible effects of these maladies (Standard & Poors Industry Survey, p. 16).

Preventing disease will continue to be a high priority; it is preferable to treatment after occurrence. Disease prevention offers the promise of better quality of life for the patient and society and contributes the economic benefits attendant to higher productivity. It also helps to avoid the high costs of health care treatment. There will continue to be increasing research interest and investment in vaccine development, patient education, and preventive strategies for disease caused by infection, cancer, and substance abuse. With the increasingly mobile global society, there is an increase in the risks associated with deadly infectious diseases. Some diseases such as Ebola, drug-resistant bacteria, hepatitis, Lyme disease, and hantavirus can have a devastating effect on society. These diseases will be demanding increased attention from researchers over the coming years.

Much research will be conducted at the genetic level as scientists attempt to understand the role of genetics in the pathology of disease. The genetics puzzle associated with cancer, brain disorders, and inherited conditions, will draw the attention of researchers as will vaccines and treatments for genetics-related diseases.

Lastly, longer lifetime exposures to toxic agents, such as tobacco, fat-laden diets, petrochemicals, and lifestyle diseases, will provide ample investigative subjects for biomedical researchers.

Conclusion. Apparently, a public consensus exists to support the continued expansion of federal investment in this area. As the population ages, more people, sensing their own mortality, seem willing to devote an ever-increasing percentage of the national wealth toward finding answers to the problems of aging, disability, and disease; and finding ways to live longer, more productive lives.

This, in turn, nurtures a biomedical research establishment that clamors for government funding. The large federal research investment will continue to spur the tremendous growth of the health care, medical devices, and pharmaceutical industries. American businesses in health care related fields are experiencing a period of robust growth, which is expected to continue in the near future. While the nation debates where to place the limits on health care expenditures and attempts to answer moral questions about America's responsibility to the rest of the world, the scientific community will continue to expand the horizon of what medical interventions can provide.

Essay 3: Reorganizing US Military Medical Forces for the 21st Century
(LTC Greg Jolissaint, USA)

The military service medical departments cannot adequately perform their combat readiness, operational support, and peacetime healthcare missions without major reforms. If the primary mission of the service medical departments is combat medical readiness, then combat medical readiness must be made the number one priority.

TRICARE. TRICARE, DoD's healthcare management system similar to HMOs, is scheduled for full US implementation by the end of 1998. TRICARE is giving the service medical departments the ability to train for their wartime medical missions and to support operational deployments while ensuring timely access to quality medical care for all military beneficiaries. TRICARE contracts have been written to ensure increased access during operational deployments of military medical personnel.

Current Medical Force Authorization. The DoD Medical Readiness Strategic Plan 1995-2001 (p. 11) states:

"The composition of the total military medical force is determined by the mission and population of the military force it must support. Included are the medical forces deployed in a theater of operations, other overseas military medical requirements, the Continental US (CONUS) military medical training base, and the military medical force needed to provide preventive and restorative care in CONUS to the mobilizing population and to patients evacuated from outside CONUS.

The Active Component (AC) will be sized to provide immediate contingency response until mobilization and deployment of the Reserve Component (RC) can satisfy mission needs. After consideration of the force required for war preparation, the size of the AC is adjusted for any additional requirement to provide health care to the military force and family members forward deployed. Finally, additional adjustments to the size of the AC can be considered if the Military Health Service System (MHSS) can provide more cost effective health care to beneficiaries."

USACOM Functional Plan 2508-96. The US Atlantic Command (USACOM) has developed Functional Plan 2508-96, "Integrated CONUS Medical Operations Plan (ICMOP)." This plan provides planning, coordination, and integration of all CONUS military medical activities in wartime (to include expansion of the military medical

training base). It also includes a provision for preventive/restorative care for the mobilizing population and medical care for military patients returning from outside CONUS who will return to active duty in a reasonable period. USACOM coordinates with the Department of Veterans Affairs and National Disaster Medical System (NDMS) hospitals to ensure military patients not being returned to active duty receive appropriate care (The DoD Medical Readiness Strategic Plan 1995-2001, p. 13).

Joint Health Service Support Vision 2010. Joint Vision 2010 and Joint Health Service Support Vision 2010 (JHSSV 2010) describe smaller, more flexible, 100% mobile medical forces supporting US and allied forces in a theater of operations. There is ongoing debate in Congress and the Pentagon concerning the feasibility of greater downsizing of the military medical services. These discussions originated because, since 1991, there have been small reductions in personnel in the service medical departments. Yet, the vision for the 21st century is for smaller deployed medical force requirements.

Proposed Changes for DoD Medicine. Service medical personnel authorizations should be based on the essential number of personnel needed to deliver combat health support to all deployed soldiers (active and reserve). Fixed medical facility (TDA) authorizations should reflect the essential TDA medical cadre required for integrating medical contractors into the operation of TDA medical facilities during operational deployments. TDA authorizations should incorporate all medical personnel actively enrolled in the Uniformed Services University of the Health Sciences and all physicians enrolled in military medical internships and residencies. Consideration should continue to be given to authorizing military physicians to provide health care to forward deployed soldiers and their families (when outsourcing is unavailable, too expensive, or of "less than US quality").

Provisions for back filling TDA hospitals with reservists should be eliminated. All reserve medical professionals should be reallocated to fill reserve deployable hospitals. This reallocation will eliminate reserve physician and nurse shortfalls and facilitate the medical readiness of reserve hospitals. Nondeployed AC physicians and nurses (those not assigned to critical, deployable AC unit leadership positions or those not actively involved in critical, full time AC training roles) should continue to practice their skills at all TDA medical facilities.

TDA facility leadership should ensure assigned medical personnel are actively involved in health care delivery (to ensure maintenance of medical and nursing skills). TDA facility leadership and deployable medical unit leadership (active and reserve) should ensure assigned

medical personnel participate in regular, high quality combat readiness training with their designated wartime unit. DoD Health Affairs should ensure implementation of quality, relevant preventive medicine programs for all active and reserve soldiers.

For wartime TDA authorizations, medical personnel authorizations should not include staffing TDA medical facilities during "two nearly simultaneous major regional contingencies." A system already exists that mobilizes civilian and federal healthcare facilities for the reception of wartime casualties. USACOM's Functional Plan 2508-96 mobilizes the Department of Veterans Affairs and the civilian health care industry to receive casualties from military conflict or disaster. Instead of authorizing "military medical forces needed to provide preventive and restorative care in CONUS to the mobilizing population and to patients evacuated from OCONUS," DoD should allow the NDMS to operate as it has been designed. It is expensive and unnecessarily redundant to authorize active or reserve slots to fully staff TDA facilities for the sole purpose of caring for returning casualties when both active and reserve medical units are fully deployed. If this plan is executed properly, the result will be the same – US physicians and nurses will deliver high quality, state-of-the-art medical care...and employ high quality, state-of-the-art surgical techniques...to injured and sick US soldiers, sailors, airmen, and marines returning from a theater of operations.

Finally, DoD should move swiftly to mold the US military's medical forces to fit Joint Health Support Service Vision 2010. The numerous medical shortages in the National Guard and Reserves; a smaller, downsized military; and the volatile, ambiguous world situation in the post-cold war era, all warrant a reorganization of DoD's medical forces.

Conclusion. The processes and formulas for authorizing military medical personnel must be revised to support peacetime healthcare, operational deployments, and 21st century medical readiness requirements. TRICARE should allow these proposed changes to be formulated and implemented soon.

With the fall of the Berlin Wall, and the lack of a credible military threat to US national security, it is time for our military medical departments to complete their downsizing process. DoD medical force reorganization will ensure a high quality 21st century medical force and a high quality medical system for all military health care beneficiaries.

Essay 4: *Ethics of Health Care Delivery* (CAPT Scott Thomas, USN)

Few issues affect the public today as does health care and its future. Just mentioning topics such as HMOs, genetic engineering, Medicare, and physician-assisted suicide generates fervent and controversial dialogue. Any discussion or policy decision concerning health care delivery invariably becomes an ethics issue. Advances in technology and scientific discoveries have blurred public opinion on the basic question "When is death, death?" As our society debates these issues and the government makes decisions about them, the one constant we can depend on is change. As we move into the 21st century, making ethical decisions will be complicated and challenging due to the rapid pace of medical progress.

If we examine other perspectives, we can reach a consensus on some health care delivery and ethics issues. To address moral and ethical issues in the field of health care delivery, the following perspectives are being applied: theological, academic, HMOs, and government.

Theological Approach. This approach adheres to what the Bible teaches. However, even devout Christians have difficulty reaching consensus on many medical ethics issues. The Christian Medical and Dental Society (CMDS) is a leading organization working to bring medical care more in line with religion; it has chapters in two of every three medical and dental schools in the country. CMDS believes that physicians and dentists should integrate their Christian faith with their professional practice. Its biblical model for medical ethics states: "Christians believe in the divine inspiration, integrity, and final authority of the Bible as the Word of God." Millions of Americans agree that the Bible provides the background and guidance needed to make difficult ethical decisions. Theologically, their health care ethical decisions will have a fairly systematic approach and predicable outcome.

Academic Approach. This perspective suggests that one learns what is right and wrong in the classroom, at home, or from society. Every major university and military medical center have established departments to deal with the growing complexity of medical ethics questions and the decision making process for finding resolutions vice concrete answers to these issues. The University of Pittsburgh Center for Medical Ethics is based upon the premise that the questions posed by contemporary health care dilemmas are not the province of any single discipline, but require the collaborative integration of insights garnered from history, law, medicine, philosophy, and the social sciences (University of Pittsburgh, p. 1).

In searching for common ground between the theological and academic perspectives, it is interesting to note research has been conducted that may link prayer with medicine and healing. Increasingly, medical academic institutions are exploring the role of prayer in healing and offering courses on spirituality and health ("Research Starts..." p.1). Though melding the theological and academic attitudes of ethical health care delivery is growing, significant differences exist and will possibly increase with advances in medical technology. To resolve these differences, we must search for and understand the commonalties between the theological and academic perspectives.

HMO or Financial Approach. The HMO is based on a financial approach to determine right from wrong. Managed care has become the incendiary element in health care ethics, with many issues requiring resolution.

Hospital and health care executives are facing situations of ethical conflict more often. We are now seeing HMOs turning to the academic environment for assistance in understanding the complex issue of ethics in health care delivery. Thus, college and graduate level programs in hospital and health care administration are offering training courses in medical ethics to assist executives in dealing with ethical and moral decisions.

Government Approach. Perhaps government should decide the health care ethics issues of right and wrong. There are hundreds of laws that do just that, so why not a few more? Should the government regulate health care ethical issues for everyone based on the consensus of the majority? This is a difficult or impossible task.

In 1993, Americans strongly voiced their opinions about meshing policy with health care. Several issues were at stake, including having many of our moral choices in health care decided for us. While there are strong feelings on both sides of federally regulating managed care, a consensus on how and what to regulate probably won't be forthcoming soon.

The theological, academic, HMOs, and government institutions must be ready and willing to reach consensus on ethical health care delivery as advances in medical science and technology progress and open new avenues to approach and resolve these complex issues. Searching for one right answer or approach will undoubtedly fail due to the complexity of the issues and multicultural make up of America. We must:

- Continue searching for ethical links between the theological and academic viewpoints. If prayer and spirituality can be proven to cure or ease illness, we immediately have affordable health care.

- Increase ethics training for medical personnel and HMO management. The more these individuals understand opposing views, the more likely they are to be part of a consensus resolution. As HMOs become more competitive, they will find this training provides an edge in customer relations, which equates to increased business.
- Ensure the theological, academic, HMO, and government perspectives are closely examined before passing any legislative action regulating health care. Ethics in health care delivery is no different from ethics of any other kind. Knowledge and understanding of the issue at stake will make all the difference in the world.

Essay 5: *Alternative Medicine* (Ms. Sally Gober, Dept. of State)

Alternative medicine is defined as “those practices used for the prevention and treatment of disease that are not widely taught in medical schools and not generally available in hospitals” (Barrocas, 1997). Encompassing a wide spectrum of techniques and emphasizing a mind/body/spirit relationship, alternative medicine enlists a patient’s own attitudes and emotional resources to promote healing.

Many of the practices involved in alternative healing are benign yet effective. Massage therapy, acupuncture, and chiropractic methods have become acceptable practices. While some regard them with skepticism, they serve to humanize treatment and give patients a sense of actively participating in controlling their health. However, there many unconventional therapies included under the alternative medicine rubric. These therapies, scorned by traditional practitioners as fraudulent and quackery, are often not validated, of dubious value, and surrounded by secrecy and mythology. In spite of the lack of objective evaluation and unscientific practices, many alternative practices are rapidly moving into the mainstream and are being accepted by traditionalists as a possible adjunct for allopathic medical practices.

Prestigious medical organizations such as National Institutes of Health (NIH) and the American Medical Association, and universities (such as Harvard, Stanford, Georgetown, and Columbia) are beginning to appreciate the healing value of certain alternative therapies. These therapies are inexpensive, nontechnical, and natural. They focus on self-care and concentrate on the treatment of the individual rather than the disease. Alternative therapies humanize medicine by placing control within the patient’s grasp. They alleviate the scary, soul-destroying

experience of allopathic treatment and are becoming accepted as an alternative technique to complement traditional Western medicine.

NIH and more than 50% of conventional physicians in the US who use or refer patients for some type of complementary alternative medicine treatment have found that these unconventional therapies are best for treating chronic diseases (allergies, arthritis, insomnia, etc.), rather than life threatening medical conditions (Jonas, 1998). Alternative practices are user friendly and inexpensive because they are simple and nontechnical and use drugs that are rarely toxic. For example, NIH found that a naturopathic prescription of the Saw Palmetto plant used to treat an enlarged prostate was more effective and cost the insurer or individual \$8 a month. In contrast, the prescription drug Finasteride was less effective and cost an individual \$50 to \$75 a month. Further, something as simple as acupuncture has been found to relieve depression as effectively as drugs or psychotherapy (Weber, 1996).

According to Weber (1996), "One in three American adults (primarily well educated, middle-income whites from 25 to 49 years of age) relied on an unconventional treatment for a health problem in 1990. Americans also paid more visits to alternative practitioners that year (425 million) than they did to their primary care physicians (388 million), spending a whopping \$13.7 billion in out of pocket expenses." Alternative therapies, as an adjunct to traditional medical practices, are clearly here to stay. In 1991, Congress asked NIH to establish the alternative medicine office to screen and determine the clinical benefits, if any, of natural medicine. Alternative therapies work well, as complements to traditional medicine, but consumers need to have a realistic perspective to guard against unscrupulous practitioners.

CONCLUSION

In this period of major transition and turmoil for the US health care industry, there is reason for optimism, though tempered with concern. The greatest challenge to military medicine is "right-sizing" the medical force to ensure both military medical readiness and access to high quality care for all military beneficiaries. Perhaps the most critical challenge to government and the industry overall is to remember that patient care is as important as ever, even as cost and profit increasingly constrain decision makers in the industry. Also crucial is the need for thorough examination and debate on the ethics and safety of emerging health care technologies and methodologies. The issues highlighted by the study group should serve as a stimulus for discussion and a catalyst to attain comprehensive access to affordable, quality care in the US.

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INFORMATION

ABSTRACT

The information industry is a cornerstone of America's economy and national security. Dramatic growth and expansion of the industry are likely in the 21st century, as computers, telecommunications technologies, and innovative information services continue to converge and evolve rapidly, and transform the way we live and work. The American information industry remains preeminent in an increasingly global market. Still, the industry must address key challenges to maintain American preeminence. The nation's educational system is not meeting the industry's ever-expanding need for trained professionals, leading to a growing reliance on foreign talent. Another challenge is protecting the national information infrastructure from attack or catastrophic malfunction. Government must work with industry to resolve these and other issues, which include protecting intellectual property rights, ensuring fair competition within and among domestic industries, reducing unnecessary regulation, and actively supporting industry's interests in multilateral and bilateral trade arenas.

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PLACES VISITED

Domestic

3COM Corporation, Santa Clara, CA
AirTouch Communications, San Francisco, CA
Apple Computer, Cupertino, CA
AT&T Network Operations Center, Bedminster, NJ
BBN Technologies, Arlington, VA
Bell Atlantic, Washington, DC
Bell Corporate Research (Bellcore), Morristown, NJ
Chancellor LGT Asset Management Co., San Francisco, CA
Federal Communications Commission, Washington, DC
Information Technology Association of America, Arlington, VA
Intel Corporation, Santa Clara, CA
Microsoft, Washington, DC
Netscape Communications, Mountain View, CA
Oracle Corporation, Redwood Shores, CA
Silicon Graphics Inc., Mountain View, CA
Sun Microsystems, Menlo Park, CA

International

Compaq Computer, Shenzhen, People's Republic of China
Consulate General of the US, People's Republic of China
Guang Dong Nortel, Shunde City, People's Republic of China
Guang Dong Posts and Telecommunications Administration, People's Republic of China
IBM Joint Ventures, Shenzhen, People's Republic of China
Asian Technology Information Program, Tokyo, Japan
Ministry of Posts and Telecommunications, Tokyo, Japan
National Panasonic, Tokyo, Japan
Nippon Motorola Ltd., Tokyo, Japan
Sony Corporation, Tokyo, Japan
Tokyo Stock Exchange, Tokyo, Japan
Agilis Communications Technologies, Singapore
Economic Development Board, Singapore
Hewlett Packard, Singapore
National Computer Board, Singapore
National Science and Technology Board, Singapore
Tech Semiconductor, Singapore
Telecommunication Authority of Singapore

INTRODUCTION

The Information Age represents a profound revolution in human affairs, preceded in history by the industrial and agricultural ages. Behind the label, Information Age, is the information industry, the primary engine of this revolutionary change. The technologies and paradigms produced by the industry are ubiquitous, affecting virtually all private and public sector entities of American society. As such, the information industry is a critical lynchpin of US national power, not only economically and militarily, but also socially and culturally.

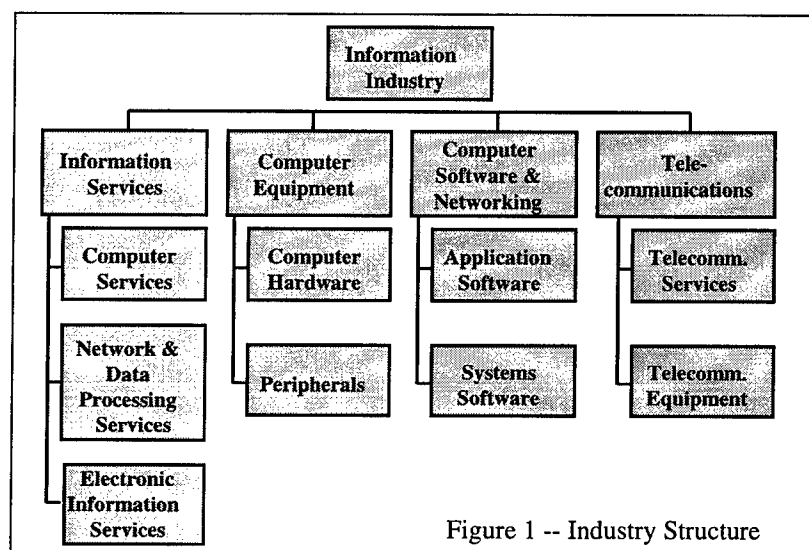
The industry is marked by a trend toward convergence. Boundaries between traditional sectors and segments of the industry—computer systems, telecommunications, and information services—have not only become blurred, but are on the verge of complete fusion. A key agent for convergence is the growth of the Internet or the networked environment, which brings together distinct technologies and industry segments in an increasingly seamless way. Finally, the information industry is dynamic, perhaps to an unprecedented degree. Increasingly, firms are global and international in orientation. Profound changes in the industry are measured by months instead of years. Change is marked not only by the rapid advance of technology, but also by the speed at which the business landscape shifts, as mergers, acquisitions, startups, and breakups come at a dizzying pace.

The purpose of this report is to assess the current and projected state of the industry, to identify the challenges it faces, and to address how industry and government should respond to those challenges. Some important questions this report addresses follow. What is the state of the information industry? How does the US compare with the rest of world? To what extent are the Department of Defense (DoD) and other elements of the national security apparatus prepared to defend the US against information-related threats? What are some of the challenges to the US competitive position, and what are some challenges society faces in incorporating and absorbing these new technologies? Finally, what should government's role be in confronting and addressing these challenges?

THE INFORMATION INDUSTRY DEFINED

The rapid development of new trends in the information industry makes a consistent market segmentation difficult. This analysis focuses on information services, computer equipment, computer software networking, and the telecommunications industry. Figure 1 shows the corresponding subsectors within each of these industry sectors.

Figure 1. Industry Structure



CURRENT CONDITION

Information Services

The US is the world leader in professional computer services, a subsector that includes systems integration, custom computer programming, consulting, training, database recovery, and facilities management and maintenance. This subsector makes up over half of the US information services market; it is the fastest growing subsector, expanding by over 15% each year since 1993 (DRI/McGraw-Hill, Standard & Poor's, and US Department of Commerce, p. 26-5). This level of growth can be expected to continue in the coming years due to business demand for client/server architectures, the increasing complexity of information technology products, and the need to integrate them successfully into businesses' operations.

The number of network and data processing service companies that offer a broad range of services (electronic data interchange service, electronic mail delivery, file transfer, and electronic funds transfer) is growing. Between 1994 and 1996, the combined subsector grew from \$29 billion to more than \$42 billion, an increase of over 13% per year. Spending on network products and services has been boosted by the

continued expansion of the Internet and has generated a concurrent demand for network services. Global revenues from networking products and services increased 21% in 1996 (DRI et al., p. 26-7). US sales of networking equipment to Japan, Australia, Singapore, and Hong Kong grew at double-digit rates in 1996 and at triple-digit rates in less developed Asian and Pacific Rim countries. Although traditional data processing services still have strong growth opportunities, the demand is for automated routine functions as individual businesses worldwide build their own information technology bases. US companies capable of providing these services on a large scale stand poised to benefit greatly from the developing international information technology infrastructure.

The electronic information services sector provides proprietary databases and information either on-line, via CD-ROM, or through other mediums such as disk, tape, or audiotext. It is the smallest segment of information services; it generated revenues of only \$5.9 billion in 1997 and grew less than 9% during the same period (DRI et al., p. 26-8).

An important part of this subsector is consumer online services, which give subscribers easy access to a wide array of information and data. The home-based market for personal computers has grown 70-100% yearly, and is expected to continue through 2000, due, in part, to the price drop of personal computers with high-speed modems. Consumers are now spending more than \$4 million a day on products purchased online; shopping revenues are expected to reach \$17 billion within the next 3 years (Forrester). Although online consumer providers are aggressively pursuing overseas markets, growth will be significantly slower than in the US market.

Computer Equipment

The convergence of the computer, communications, and consumer electronic markets into one market, and the emergence of a worldwide consensus to construct a Global Information Infrastructure are the driving factors in today's computer equipment industry. Many traditional computer suppliers are shifting away from hardware production to software and computer services in an attempt to redefine themselves in the information age. Many companies have formed strategic alliances with regional leaders in an attempt to increase market share. The global demand for computer and networking equipment is sparked by the development of national information superhighways (particularly in the big emerging markets of Asia), by corporate plans for intranets and local area networks (LANs), and by the growing home computer market.

The US-based computer industry's product shipments have risen at a healthy rate of 14% per year since 1992, resulting in an estimated \$91 billion in 1996. The US continues to enjoy world leadership, controlling 76% of the world's markets for supercomputers, 60% of mainframes, 61% of mid-range computers, and 67% of desktops. The US is still the leading exporter in global computer trade, but its market share has declined by more than 25% since 1989. However, this does not reflect US computer firms' substantial contribution to overseas production of the exports of several other major exporting countries, particularly Singapore and European Union nations (DRI, pp. 27-2 to 27-5).

Asia is the principal source of US computer equipment imports. The top five countries of origin for these imports in rank order are Japan, Singapore, Taiwan, South Korea, and Malaysia. These five countries accounted for 71% of the \$60 billion total imports for 1996. Foreign competition aimed at eroding US dominance is intensifying. The principal competition is coming from Asian suppliers who have announced their intentions to wrest control away from their US rivals; they pose a challenge in high-performance systems and personal computers. Meanwhile, foreign direct investment in the US computer industry has been relatively small when compared to overseas investment by US computer firms. Because of this wide disparity in investment, by 2002, the overall US computer trade deficit should grow to an estimated \$57 billion, nearly twice the 1998 level (DRI et al, p. 27-5).

Continued domestic and foreign demand for computer systems and networking equipment should boost the US computer equipment industry's product shipments by 10% in current dollars to an estimated \$111 billion in 1998. Domestic computer demand could reach \$141 billion as businesses upgrade to more powerful PCs and begin purchasing network/thin client models. The home user sector will become a more important factor in US demand, due to continued decreasing costs. Multimedia PCs with true 3-D graphics and digital videodisk capabilities should spark demand for replacement of systems at the high-end of the home market.

The reemergence of network-centric computing will also shape the demand for computer equipment. The US and the major developed markets overseas will focus their attention on building intranets within their organizations and linking more of their personnel and regional or global operations through the Internet. The primary markets for this will be large corporations within the big emerging markets in Asia, as markets in the US and Europe become more saturated.

The popularity of mobile computing and cellular telephones is an indicator of future trends. Small hand-held devices will become more

advanced and affordable, contributing to additional growth in the industry. The portable computing share of the market is currently 20% of the overall market and should reach 30% by the year 2000 (DRI et al, p. 27-13).

US-based computer industry employment could drop by 25% between 1994 and 2005. A major cause is the ongoing shift of US computer firms from equipment manufacturing toward software development and services such as systems integration, computer maintenance and support, and facilities management.

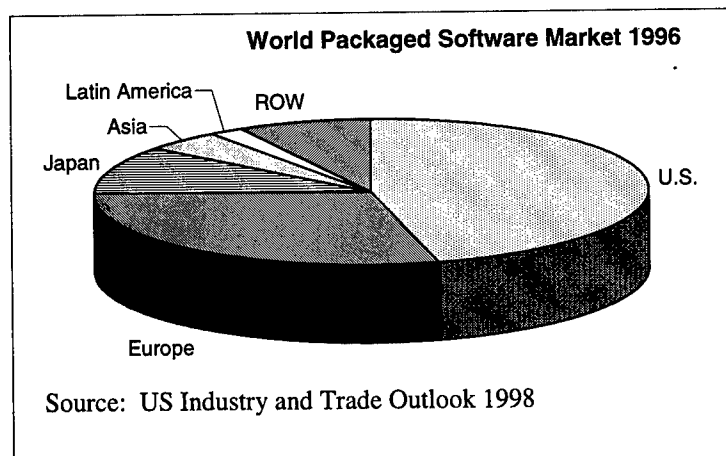
The sources of future demand for US computer equipment suppliers should not only continue to be customers in traditional export markets, but also those in the big emerging markets, most notably China, Brazil, and South Korea.

Networking and client/server technologies have enabled the PC to play a greater role in mission-critical business functions, which expands its value to companies and reduces the status of legacy mainframe and midrange systems. The growth in network server sales parallels the spread of networks.

Computer Software and Networking

On the demand side, the global market for packaged software was worth \$109.3 billion in 1996. The US share accounts for \$50.4 billion or 46%; it will continue to have the world's largest share, followed by Europe (32%) and Japan (11.4%) [see Figure 2]. The high US market

Figure 2. World Packaged Software Market 1996



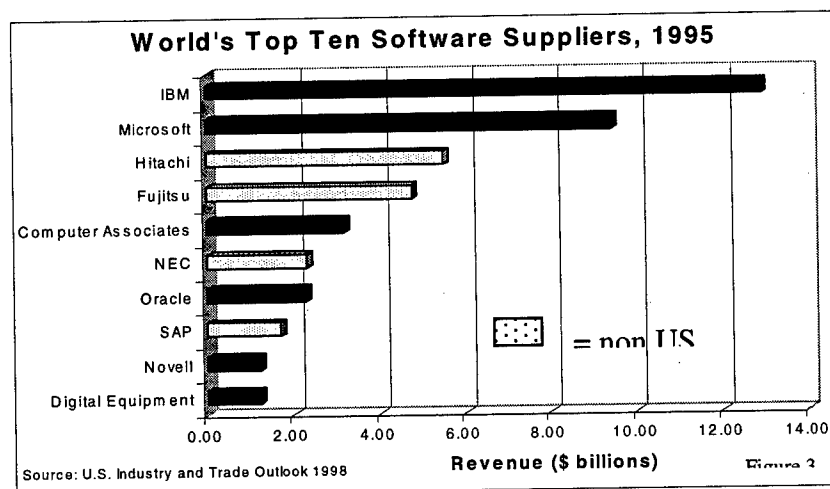
share is accompanied by an expected robust growth of 12% through the year 2000, slightly higher than the global average growth rate. However, the relative share of the US software market has declined from 56% in 1994, due to the rapid growth in new developing countries, especially Asia and Latin America. The current turmoil in Southeast Asian economies may slow down this process, but will not reverse it in the long-run. China is expected to post the largest gains (57% annually). As a consequence, international sales remain a vital revenue source for US vendors. To remain successful, they will have to enhance the international orientation of their business.

Another way to frame the industry is according to the different types of computers the programs operate, from PCs to mainframes and even supercomputers. Standard & Poors estimates that the PC software market totaled \$25 billion in 1996, with Microsoft commanding a 40% share of those revenues (Lohr, p. D2). The mainframe software market is roughly one and a half times as large as the PC segment, at an estimated \$35 billion. The remainder of the market consists of software installed in other computers such as minicomputers and workstations.

The development of the software market is strongly correlated with trends in the computer equipment segment. The effect of platform downsizing (i.e., the shift away from mainframes and minicomputers to PCs and workstations) has spurred growth in the PC software market to an annual rate of more than 35%, whereas growth rates in the mainframe and minicomputer markets are declining to less than 10%. The triumph of network solutions in business, and increasingly home-based applications, has spurred the market for networking software, including network operating systems, network management tools, and database management systems.

On the supply side, the US industry has continued its leadership in the global marketplace. Although there is no detailed data available, revenues of US companies account for approximately 75% of the global market. Figure 3 shows that six of the ten companies with the largest worldwide software revenues are headquartered in the US. Japan was the closest competitor, accounting for three, with the remaining company coming from Germany.

Figure 3. World's Top Ten Software Suppliers, 1995



The concentration ratio in the software market seems to be moderate. The first three firms account for some 30% of the market; the largest 10 firms represent a market share of approximately 47%. The remaining 53% are fragmented, representing firms with less than 1% of market share. Although Microsoft has only a market share of 10% in the packaged software market as a whole, its Windows software is used on more than 85% of the world's personal computers and is the dominating operating system in this segment.

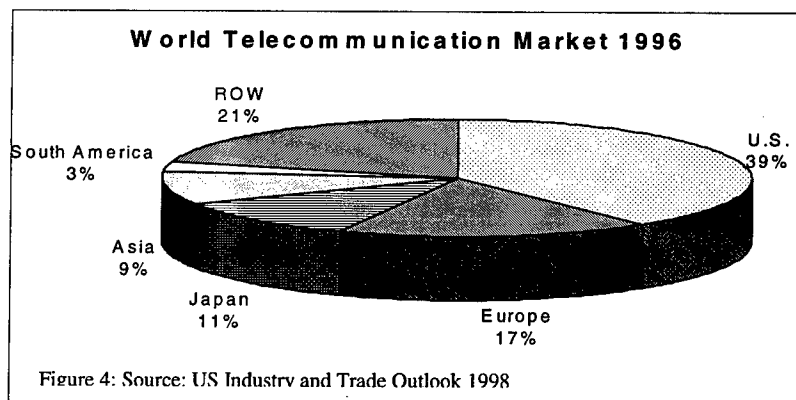
The packaged software industry is an important source of employment in the US. The Bureau of Labor Statistics reports that the packaged software industry employed 206,300 people in 1996, a 13% increase over 1995. In addition, it is a major technology driver in the US economy. Estimates for 1997 indicate an increase of R&D spending by 20%, to \$10.3 billion, the second largest amount of corporate R&D in the economy.

In an international comparison, the US and Japanese software industries show different development paths. In the US, new firms are very prominent, but in Japan established producers (especially mainframe computer manufacturers) are more important. This occurs because of different national financial systems (e.g., the availability of venture capital) and intellectual property rights rules. The Western European software industry occupies a middle ground. Compared to the US, there have been fewer new market entrants, but European computer manufacturer's weakness has prevented their software subsidiaries from becoming as strong as their Japanese counterparts.

Telecommunications

Encompassing both telecommunications equipment and services, the US continues to be the dominant leader in the global telecommunications market. The world market has dramatically increased since the opening of European Union markets to competition in January 1998 and the expansion of the Asian economies, especially China. Global telecommunications equipment revenue has grown from \$180 billion in 1996, with anticipated growth to \$208 billion in 1998. Revenue in the global telecommunications services market exceeds \$725 billion and is expected to grow 12% annually to over \$900 billion in the year 2000 (DRI et al., p. 30-10, 31-2). The US accounts for nearly 40% of these markets, generating revenues of \$406.7 billion in the equipment and services sectors (See Figure 4). The growth of the global telecommunications market is attributed to several factors: the increased demand for processing larger volumes of information, the desire to integrate voice and data, greater interoperability derived from the advancement of standards, and an expanding international market (Grace).

Figure 4. World Telecommunications Market 1996

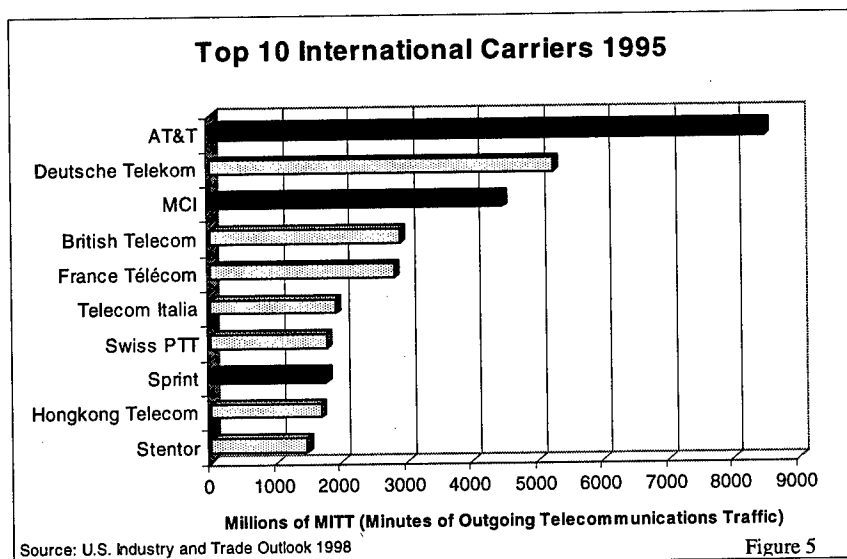


Although current economic conditions in the industry are positive, turmoil still remains after the passage of the Telecommunications Act of 1996. The act provides local service providers, such as the Regional Bell Operating Companies (RBOCs) or the Incumbent Local Exchange Carriers (ILECs), the ability to enter the \$90 billion long distance market. Several RBOCs have applied, but all applications have been rejected based upon the Federal Communications Commission's (FCC's) opinion that they have failed to demonstrate, through a 14 point

checklist, that they have opened their local markets to competition (Gruley and Mehta, p. A3). Although competition is improving slightly, of the nearly 1,350 local telephone service companies and over 500 long distance companies in the US, about 12 large companies control 90% of revenues in the industry.

The telecommunications equipment segment has remained economically strong, but the 1996 act has affected it. By removing barriers to competition, the act will potentially stimulate the demand for equipment by service providers. However, until the critical regulatory issues are resolved, many telecommunications companies are delaying procurement of equipment pending the formulation of business plans that accommodate regulatory change.

The international market is going through dramatic change in 1998. Based upon the World Trade Organization (WTO) treaty signed in 1997, 69 members of the WTO are moving towards privatization and competition. In January 1998, the European market opened to competition; it is anticipated that this market will grow annually by 13%, exceeding growth in North America. In Asia, China plans to invest about \$60 billion in its telecommunications infrastructure by the year 2000, and new investment in India could reach \$35 billion. In other areas of the world, it is estimated that developing countries will need \$60 billion over the next 5 years to implement necessary improvements to their information infrastructures (DRI et al., p. 30-4). Figure 5 indicates that the US carriers are well prepared for the international competition.



Increased demand for information services and global electronic commerce opportunities are stimulating privatization, growth, and competition in the international market. The result will be lower prices and greater availability of new information services.

As we move toward the 21st century, privatization, competition, universal service, and technology expansion will propel the industry to unprecedented levels of growth. The trend toward mergers and joint ventures will continue for the near future as domestic and international markets find equilibrium. The industry has witnessed over 9,000 mergers in the past 3 years, totaling more than \$458 billion. It is likely that the industry will see increased arrangements as companies seek to cultivate emerging markets (Fusting). New business opportunities will emerge for US firms as Europe, Latin America, and the Far East open their markets. US exports grew by an estimated 24% in 1997; this trend will continue into the next century (Grace). US firms are positioned for success in these emerging markets. Intellectual capital and infrastructure investments give US companies an advantage, resulting in higher productivity and efficient economies of scale.

The expanding role of wireless communications will have a continuing impact on the telecommunications industry as a whole. The global demand for wireless information service is expected to reach 600 million customers by year 2001. The US currently has 57 million customers — that figure is expected to double within the next 5 years. When one realizes that wireless services penetrate only 1% of the world's population, and given that much of the world is without wireline communications, more and more countries are turning to wireless as its communications system of choice. Deployment of Low Earth Orbiting(LEO) satellites providing global wireless service (such as Iridium and Globalstar) demonstrates a new approach to the increased demand for information anywhere at anytime. Expanding opportunities in foreign markets should fuel growth in the US telecommunications industry. US companies, often in partnership with a host-country firm, already have won more than 160 bids to build and operate cellular networks abroad.

Standardization of protocols in all areas of telecommunications is one of the critical factors facing the industry. Incompatible formats exist today within the digital wireless segment as well as other segments of the industry. A standards-based architecture is required to achieve an effective national and international system that is seamless and transparent to users. This will provide a basis for unprecedented growth in the telecommunications industry for the next decade.

The industry has examined the feasibility of fiber to the home (FTTH) deployment. By the year 2000, broadband services should be widely available to residential customers, especially in view of the large anticipated demand for entertainment services. If FTTH proves to be economically justified, demand for optical fiber in the US may expand tremendously. Japan, the largest Asian fiber market, has identified fiber optic technology as the leading technology for building its FTTH project by the year 2010. China has become the second largest market in the region in terms of installed fiber, and it is one of the fastest growing markets worldwide.

CHALLENGES

Several challenges and issues are likely to influence the growth of the information industry. First, there are regulatory and trade-related factors that could affect the extent to which information firms can compete both domestically and internationally. Second, there are critical workforce issues that threaten to limit the growth of the industry. Third, challenges surround the integrity and reliability of the information infrastructure.

Competition and Free Trade

The domestic telecommunications industry has traditionally been regulated in the US to ensure fair competition and universal service. Competition within the computer industry has largely been left unregulated by the government, although enforcement of antitrust laws could affect the competitive landscape.

Internationally, trade-related factors and protection of intellectual property rights will likely have an impact on all segments of the information industry as firms seek to expand into global markets. Theft of intellectual property is a significant problem. In the software industry alone, the estimated worldwide revenue losses due to piracy amounted to \$11.2 billion in 1996. According to the Software Publishers Association, "over 45 percent of US software company revenues are generated overseas. Nearly 75 percent of piracy losses occur outside US borders; 25 percent of the countries surveyed had piracy rates greater than 90 percent."

Development of the US Workforce of the 21st Century

Maintaining a skilled and trained workforce is one of the greatest challenges facing the information industry. According to the Information Technology Association of America (ITAA), there are 346,000 programmer, systems analyst, and computer-engineer positions currently vacant in the US (Torode). Demand is outpacing supply, causing worker shortages and wage inflation. Vacancies take longer to fill and turnover has doubled at many companies. More and more domestic firms are looking overseas for talented IT professionals.

To address the shortage of skilled IT professionals, many firms offer monetary incentives, encourage supportive organizational cultures, and collaborate with educational and training institutions to attract talented employees. In addition to these measures, industry should also consider creating more entry-level positions to be filled by college graduates or technicians; developing programming interfaces that enable the syntax of existing spoken languages to be used for computer coding; and recruiting eager foreign nationals, until more US IT professionals can be trained and employed.

Information Infrastructure

Providing a reliable and secure National Information Infrastructure (NII) is key to the growth of not only this industry, but also the overall economic well being and security of this country. There are several issues that must be resolved, including vulnerability to information attacks, encryption, and the year 2000 (Y2K) computer problem.

Protecting Against Information Attack. Computer intrusion (popularly referred to as "hacking") is a growing challenge for government and industry. Many companies victimized by an information attack often don't detect it, write it off as a cost of doing business, and/or don't report it for fear of destroying consumer confidence. Information attacks on companies can result in intellectual property loss, schedule setbacks, strategic plan exposure, stagnation of R&D development, loss of consumer confidence, and diminished market share.

Because the information infrastructure underlies everything from electric utilities to telecommunications networks, vulnerability to computer intrusion is a significant national security issue. According to the *Washington Post*, "the lack of cooperation between government and private industry has undercut development of a common defense against what security experts have labeled 'information warfare'" (Graham, p. A6). Though many private, public, civil, and military organizations are

doing a credible job in combating computer intrusion, underreporting hampers their efforts. The problem is likely to get worse as motivation among long-time hackers has, in many cases, shifted from curiosity and challenge to financial gain. Of equal concern is the possibility that terrorists or hostile foreign entities may launch information attacks that could cripple America's information infrastructure.

Encryption. Utilization of the national information infrastructure (including the growth of electronic commerce) will be limited if businesses and the public lose confidence in the integrity and security of the network. Encryption is one way to protect transmitted information. Recipients of information must use an electronic key to decipher the message; the more stringent the level of encryption, the harder it is to "break the code." Many Internet users are demanding higher levels of encryption to prevent confidential or proprietary information from falling into the wrong hands. At the same time, government and law enforcement officials worry that they will be unable to monitor electronic communications among criminals, terrorists, or hostile foreign entities. The government is arguing for access to the keys used to unravel the most sophisticated encryption algorithms produced and sold by software companies. At the same time, the government has prohibited the export of sophisticated encryption products developed by US software companies.

The policy debate focuses on where to draw the line between the rights of privacy for an individual, company, or organization, and the needs of the government to protect its citizens from terrorist and criminal activities. By only allowing the export of weak encryption algorithms, and by requiring strong encryption algorithms to have some means of key recovery or key escrowing, the Clinton administration hopes to make decryption easy for law enforcement or intelligence agencies. Meanwhile, strong encryption software is currently available internationally and is not subject to US controls. The US software industry wants to be able to export strong encryption algorithms to compete in the international marketplace. Senior industry officials estimate that export controls on encryption are costing the US \$60 billion in lost sales and over 200,000 jobs.

Year 2000 (Y2K) Computer Problem. Almost all computer-based systems will be adversely affected by the Y2K problem unless action is taken to mitigate its effects. The Y2K problem stems from software that stores calendar dates in two digit form ("1998" for example, is commonly interpreted by computers as "98.") Date information plays a major role in almost all computer applications developed over the last 30 years. Thus, when the year 2000 arrives at midnight on 31 December

1999, many software applications will stop working or create erroneous results. Already, systems are beginning to malfunction as they encounter events that project past the end of 1999.

The Y2K problem looms as a potential crisis. Y2K malfunctions could undermine the nation's information infrastructure and cripple business operations ranging from airlines to telecommunications to financial systems. Conservative estimates suggest that 25-50% of all computerized organizations will not be compliant by 2000 (Jones, p. 5). Noncompliance in other countries may be even higher.

Many major industries in the US are fixing the problem by reprogramming, migrating, or converting old software into Y2K compliant systems. Such efforts are expensive. The Gartner Group has estimated a total worldwide cost of fixing the Y2K problem at \$600 billion. Opportunity costs are also high, as many companies must divert financial resources from other worthwhile IT investments.

OUTLOOK

Information Services

The growth of intranets, extranets, and other networks is linked to the emergence of the Internet as a global communications medium. All these developments will lead to an increased worldwide demand for information services. International trade opportunities in information services will continue to increase rapidly through the end of the decade and well into the 21st century.

The professional computer services subsector should undergo strong growth except in certain areas such as custom programming. Growth in this area may level off due to the wide selection of sophisticated off-the-shelf hardware and software. Businesses continued preference for client/server architectures, the increasing complexity of new information technology products, and the need to integrate these successfully into businesses' operations should stimulate growth.

The demand for traditional data processing services and electronic information services should remain strong as the need for the most recent and accurate financial and business information requires up-to-the-minute updating.

Computer Equipment

Given the future scenario of network-centric computing, the US-based computer industry should realize 11% growth per year in current

dollars to \$170 billion in 2002. This forecast accounts for fierce price competition across the broad spectrum of computer systems and in many peripheral equipment areas, which will result in further consolidation as weaker suppliers are forced out of the market. In the next 10 years, the industry will reach the limits of silicon-based technologies. By 2007, US computer makers should develop microprocessors that exceed 1,000 megahertz and that have main memory totaling 16 billion bits (gigabits) of information.

The industry will continue to advance in the areas of voice recognition and response, automatic language translation, enhanced graphics capabilities such as visualization and simulation, and virtual reality. Computer suppliers are expected to use hybrid technologies consisting of extremely fast optoelectronic circuits and biomolecules married to semiconductors. Advances in optics should also lead to holographic storage devices with densities approaching 10 gigabytes per cubic centimeter that will allow almost instantaneous associative (pattern recognition) retrieval. Perhaps as early as the year 2003, computer scientists expect to have a commercially available hybrid system that can function as a neural, associative computer by mimicking the human brain's ability to learn and analyze data and images (DRI et al., pp. 27-5 to 27-6).

Computer Software and Networking

It is difficult to forecast the future growth of the market because it depends to a high degree on external factors. An economic recession may decrease the willingness of firms to invest in new software solutions. However, International Data Corporation and the US Department of Commerce project that revenues will grow at a compound annual rate of approximately 12% for the next several years, reaching some \$222.9 billion by the year 2002. Sales of applications solutions worldwide would rise to \$109 billion, application tools to \$66 billion, and system-level software to \$46 billion. The growth trend is expected to continue well into the next century, mainly driven by the increased demand in the areas of education, entertainment, and communications. In the short-term, fixing the year 2000 problem will also fuel growth in this industry.

The driving force for LAN vendors worldwide should be the continued expansion of the Internet, combined with the growth of intranets. Intranets are the fastest growing segment of corporate IT infrastructures, as companies worldwide adopt the technology. By the year 2000, 78% of the world's PCs will be connected or networked, fueled by user interest in network-centric computing.

Telecommunications

In the US, competition will continue to expand as cable television and long-distance providers enter the local market and as local providers meet requirements to enter the long-distance market. Local service revenues will increase in 1998 by an estimated 4% and at a constant rate reaching about \$77 billion in 2002. Long-distance service is likely to increase at an annual rate of 8%, but revenues are likely to be marginal based upon increased competition (DRI et al., p. 30-5). The telecommunications service industry will also be shaped by recent technological innovations such as Asymmetric Digital Subscriber Line (ADSL) and Internet telephony as providers seek to expand bandwidth to meet the demand for greater information. The success of these innovations will be determined within the framework of economic, regulatory, and consumer considerations.

Total US revenues for basic voice and data services are expected to grow at an annual rate of 6% until 2002, bringing industry telecommunications services revenues to \$295 billion in that year. Although voice transmission still accounts for the vast majority of cellular calls, the wireless data market is projected to have as many as 4.1 million subscribers in the US by the year 2000, compared to a total cellular market of 70 million subscribers. Wireless traffic will account for 20% of all voice calls in 2000. Sixty million pagers will be in service in the US by the year 2000, up from 48 million in 1998.

GOVERNMENT GOALS AND ROLE

The information industry is essential to future US economic prosperity and national power. Given the challenges faced by the industry, government actions should help ensure that the industry thrives in order for the American people to reap fully the benefits of the information age. Ensuring competition and free trade, developing the US workforce of the 21st century, and assuring the reliability and security of the national information infrastructure are the areas of greatest need in leadership and long-term focus.

National security will be of particular concern as American information industries globalize and foreign businesses invest in our companies. Globalization is necessary for companies to remain competitive. They must adjust their business practices to take advantage of cost reductions available by moving portions of their operations off shore. Care must be taken to ensure that technologies critical to national

defense do not become foreign tools for leveraging American political or military resolve. At the same time, government regulation and monitoring efforts must not become significant detractors to industrial competitiveness.

Ensuring Competition and Free Trade

The federal government plays an important role in fostering an environment of competition and free trade. The government should continue its strong efforts to open international markets through bilateral and multilateral agreements such as the WTO Telecommunications Agreement and the Information Technology Agreement (ITA). At home, the government must continue to promote competition and innovation through the formulation and proper enforcement of public policies. Policies must encourage competition and be formulated so that American companies competing with foreign concerns are not disadvantaged because of less restrictive policies of other nations. For example, US tax codes prevent American firms from taking advantage of tax breaks offered by other nations to foreign firms interested in doing business in those countries.

US antitrust laws can also have a major impact on competitiveness. The Department of Justice is challenging alleged monopolistic practices of Microsoft, specifically the way Microsoft integrates its Internet browser into its Windows operating system. The public policy challenge is to fuel innovation without unduly restricting competition. Innovation is imperative in order to maintain a competitive edge. The federal government must also maintain investments in long-term basic research, while providing incentives (such as research tax credits and joint ventures) to promote commercial R&D.

Open markets provide additional opportunities for innovation and economic growth. The FCC and the administration should continue to consider the distance market as an option for the local telephone service providers, while holding fast to the requirement that the local market be open to real competition first. This will get more difficult as foreign competition becomes a factor. It is imperative that the FCC and the administration monitor foreign carrier investment in the American market and seek fair international call rates to assure equilibrium in the global market. Cooperative gradual adjustments rather than unilateral change can make this palatable and advantageous.

Government must do all it can to ensure American businesses can compete on an equal basis, domestically and internationally. Internet Service Providers (ISPs) are currently getting a free ride in the local

market by not being considered service providers and therefore exempt from restrictions and fees that are applicable to local telephone companies. While this made sense when this portion of the industry was in its infancy, the ISP sector is now beginning to penetrate the local and long-distance telephony markets particularly now that bandwidth availability makes Internet telephony more viable. State and federal regulatory agencies and legislators will have to address this issue to ensure a balanced, competitive playing field in the telecommunications market.

The government must continue to apply and properly enforce copyright and patent laws that protect creators' intellectual property rights, whether that property is software, text, images, databases, video, or other media. Protecting creators' rights is an important and inherently governmental function, but these rights must be balanced with the rights of the public for "fair use" of information. Intellectual property protection is particularly critical in the international arena. The government must continue to press for stronger enforcement of international property rights through multilateral treaties such as the WTO agreement on Trade-Related Aspects of International Property Rights (TRIPS). Additionally, Congress should support the 1996 WIPO Copyright Treaties and implement the appropriate legislation to join that agreement. On a bilateral basis, the administration should fully utilize the "Special 301" provision of the 1988 Omnibus Trade and Competitiveness Act, which authorizes the Office of the US Trade Representative to impose trade sanctions against countries that deny sufficient protection of IPRs.

Developing the US Workforce of the 21st Century

The federal government should take short- and long-term actions to address specifically the shortage of IT professionals and the challenge of ensuring a technologically literate workforce for the 21st century. In the short-term, the government should immediately increase immigration quotas for trained information technology professionals from abroad to fill some of the 346,000 job openings in this country. If quotas are not raised, companies may relocate to countries where trained professionals are available.

Foreign workers are only a temporary solution to the recruitment dilemma. America's problem is twofold. The nation has a positive population growth rate, but is not producing enough information technology professionals to meet industry's needs. The nation's primary, secondary, and vocational schools are not equipping students with the

skills and motivation to enter high tech, service oriented careers. A new generation of technologically skilled Americans must be educated and trained. The government must take steps to improve computer literacy by ensuring that schools and libraries have access to the latest information technologies, including high bandwidth services. Wiring schools and libraries is an expensive proposition. Money from the universal service fund, established by the Telecommunications Act of 1996, can be used but must be balanced against other worthwhile spending goals, such as subsidizing telephone service to economically disadvantaged citizens.

Providing a Reliable Information Infrastructure

A key to global competitiveness is having easy access to a reliable, scalable, interoperative, and continually evolving information infrastructure. The President's Commission on Critical Infrastructure Protection (PCCIP) confirmed that all of the nation's infrastructures are increasingly dependent on information and communications systems, which makes them a source of rising vulnerability (PCCIP, pp. 35-37). International adversaries, unable to match our military capabilities, are also aware of this vulnerability and are working to exploit it. The threat is real and must be taken into account. It is clearly the federal government's mission to ensure the nation's security, but in the event of an attack against the National Information Infrastructure (NII) it may be industry on the "front lines" at the point of attack rather than nation's warfighter. The nation must develop the necessary mechanisms to contend with threats to the NII, synergistically combining industry and government capabilities. The National Security Telecommunications Advisory Committee (NSTAC) Office of the Manager of the National Communication System (NCS), and the NCS's National Coordinating Center (NCC) are models for effective public and private interactions to address and solve information infrastructure issues. Government needs to expand and act on the recommendations of the PCCIP by establishing a network of planning, information sharing, and warning and response cells extending from the local to the national level (National Defense Panel, pp. 25-28).

The executive and legislative branches and commercial sectors are taking divergent actions regarding data and software. The commercial sector and Congress seem to favor the development of commercial standards for encryption and greater individual privacy through minimal controls by the government on the sale and export of encryption products. The executive branch sees a need for a much greater

government role in controlling encryption and facilitating law enforcement and national security requirements over privacy concerns. This issue deserves national debate.

Finally, the federal government is affected by the year 2000 computer problem no less than private industry. Government agencies must intensify their efforts to ensure that critical federal programs do not experience disruption. They must also assist and cooperate with state and local governments to address the problem where those entities exchange information with the federal government. Avoiding widespread Y2K problems will also require close cooperation between private sector operators of critical national and local infrastructure, including the banking and financial system, the telecommunications system, the public health system, the transportation system, and the electric power generation system.

CONCLUSION

The information industry is a cornerstone of America's economy and national security. Fortunately, the US is the world leader in information technology and is likely to remain so in the near future. Dramatic growth and continued expansion of the industry is likely in the 21st century, as computers, telecommunications technologies, and innovative information services continue to transform the way we live, work, and defend the security of our nation.

Despite the robust health of the information industry, important challenges loom ahead that must be addressed to maintain American preeminence. Workforce issues are critical. America's educational system produces an inadequate number of trained information technology (IT) professionals to meet the demands of this growing industry. Partnering of federal, state, and local government with industry is needed to strengthen the integration of IT into the educational system, and to provide incentives for students in IT fields. An equally critical issue is protecting the NII. While much of the nation's infrastructure is owned and operated by the private sector, it is government's responsibility to defend national security interests in the event of an information attack. It is imperative that government and industry coordinate efforts to reduce the vulnerability of the NII.

Other actions the government can take (and has taken) to maintain a healthy information industry include protecting intellectual property rights, ensuring fair competition within and among domestic industries, reducing unnecessary regulation, and actively supporting industry's interests in multilateral and bilateral trade arenas. In sum, America's

information industry is vibrant, prosperous, and preeminent. Because it is a foundation of our national power, it is incumbent on government to ensure that this most critical of industries continues to thrive.

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LAND COMBAT SYSTEMS

ABSTRACT

For if the trumpet give an uncertain sound, who shall prepare himself to battle?" I Corinthians 14:8

Our legacy (cold war) ground combat platforms represent the most technically sophisticated, lethal, and survivable fleet of weapons systems in any military force, past or present. Altogether, they underpin the viability of land warfare as a strategic tool. The current budget cycle represents a pivotal decision point in maintaining the wheeled and tracked land combat vehicle (LCV) industrial base. Low rates of production, myopic efficiency-based acquisition reforms, and a dwindling procurement budget have combined to drain much of the flexibility from the LCV industry. Tomorrow's "come as you are war" will not abide the long lead times necessary to "cold start" a suspended industry. The LCV industry must retain warm production lines to meet the uncertain requirements of future conflicts. Current low production rates and armored vehicle modernization programs must continue to preclude the disappearance of a crucial national asset—the LCV industrial base.

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AM General, South Bend, IN
Defense Advanced Research Projects Agency, Arlington, VA
General Dynamics Corp., Sterling Heights, MI
General Dynamics Corp. (AAAV), Woodbridge, VA
General Dynamics Corp. Tank Plant, Lima, OH
General Motors Corp., Wilmington, DE
Letterkenny Army Depot, Chambersburg, PA
Mack Truck Inc., Hagerstown, MD
Program Executive Office, Picatinny Arsenal, NJ
Tank-Automotive Command, Warren, MI
United Defense Ltd. Partnership, Chambersburg, PA
United Defense Ltd. Partnership, York, PA

International

Styer-Daimler-Puch, Vienna, Austria
General Motors Canada, London, Canada
Giat Industries, Roanne, France
IVECO, Ulm, Germany
Krauss-Maffei Wehrtechnik, Munich, Germany
Royal Ordnance, Nottingham, UK
Vickers Defence Systems, Leeds, UK

INTRODUCTION

A nation that does not prepare for all the forms of war should then renounce the use of war in national policy. A people that does not prepare to fight should then be morally prepared to surrender. To fail to prepare soldiers and citizens for limited, bloody ground action, and then to engage in it, is folly verging on the criminal (Fehrenbach, p. 641).

The necessity for industry to support our military effort flows directly from the equipment we choose to employ in the field. These equipment choices are rooted in the National Military Strategy and how that strategy envisions the use of our military forces. At present, juxtaposition of our cold war footing with perceived and emerging 21st century threats creates a discontinuity in strategic preparedness. Our present weapons' inventories were developed to support a Two Major Theater War strategy and its cold war structure. However, these weapons may be ill suited to the asymmetrical tasks forecast to evolve as the dominant form in future military operations. On the near horizon, there are convergent assessments by experts, in and out of DoD, that the nature of warfare in the 21st century will not be attrition-centric.

As we look to the near future, we face an extended conflict spectrum ranging from limited duration attrition-centric warfare to protracted asymmetric stability operations other than warfare. What is not predicted, is a protracted conventional conflict such as World War I, World War II, Korea or Vietnam. Fielding and equipping agile multidimensional land, sea and air forces can only assure success in this arena. The challenge to industry is not to rebuild the arsenal of democracy, but to provide limited surge capability and sustainment over a broad range of systems including older legacy platforms and cutting-edge, technology-based weapons suites.

Only by fielding a military force capable of operating through the entire spectrum of warfare can we secure our national objectives. We must develop a viable modernization and acquisition strategy to meet these emerging future requirements. The nation must be fully capable to shape and, most importantly, respond to the full range of potential challenges. Of the top 20 modernization programs for the 1997-2001 period, a disproportionate share of modernization dollars are earmarked for aviation and naval modernization. In contrast, only a small fraction of total DoD modernization spending is targeted for land combat systems (Hawkins). The development of land combat systems (LCS) must

continue on par with aircraft and naval systems not lag behind, supported only by a flagging industry.

The LCS Industry Study Group focused on the structure, health, and outlook of the sectors that comprise the land combat vehicle (LCV) industry. The study's scope was limited to the tracked and wheeled vehicles that provide combat, combat support, and transportation functions. The most significant issues are as follows.

- The extent to which the LCV industry has the capacity to surge production, particularly of component parts, in support of a protracted conflict.
- The extent to which efficiency oriented acquisition reform initiatives aggravate the decline of the LCV industry.
- The competitive disadvantage of firms involved in defense contracts relative to an increasingly open global marketplace.
- The status of the vendor base at the component, subsystem, and supplier levels.
- The potential for government support through subsidy, partnerships, and government-owned contractor operated (GOCO) arrangements.
- The potential for modernization through spares programs to support the LCV industry.
- The ability of the LCV industry to depart from its production role and expand into life cycle support maintenance and repair agreements and dual-use manufacturing.

This report profiles current conditions in the LCV industry and explores selected initiatives that government and industry may undertake to assure a robust multidimensional power projection capability to meet an uncertain future, to accomplish our political objectives, and to protect our personnel.

THE LAND COMBAT SYSTEMS INDUSTRY DEFINED

The LCS industry encompasses a spectrum of systems that include, but are not limited to, towed artillery, small arms, land mines, command and control vehicles, and missile systems. Although the study group also considered other segments, this report is confined to tracked vehicles and tactical wheeled vehicles and the policies related to their production.

Tracked Vehicles

Tracked vehicles are designed to perform functional mission requirements in almost any terrain and to survive all known and projected threats within reasonable risk limits. Today's domestic tracked vehicles include M1-series Abrams tanks, Bradley Fighting Vehicles, M109A6 Paladin Self-propelled Howitzers, M88A2 Hercules Recovery Vehicles, Armored Combat Earthmovers, and the Multiple Launch Rocket System. Proposed systems include the Grizzly Obstacle Breacher, the Marine Corps' Advanced Amphibious Assault Vehicle, and the Crusader artillery system.

Advanced technology is applied to these vehicles to achieve additional survivability and lethality. For example, protective layers of steel, aluminum, titanium, or composite protective materials improve survivability; while advanced optics, communications, and laser capabilities supply the cutting edge in lethality—a must in today's technologically advanced and rapidly changing environment. Integration of modern command and control systems, sensors, and fire-control technology significantly enhances both survivability and lethality. It also allows smaller crews to determine precise enemy locations and to target them with lethal first-round hits, often before the enemy knows an adversary is in the area.

Improved protection often carries penalties in terms of weight that challenges the systems' maneuverability on the battlefield. Increases in size and weight also affect the deployability and strategic reach of military power in an era characterized more and more by continental US-based, but globally employed forces.

The military drawdown threatens production of specialized and complex systems unique to LCVs. Technologies involved in tracked vehicles are not applicable to traditional commercial vehicle manufacturing, and combat systems rely on specialized materials and processes that are not easily available. Trends toward industrial consolidation, internal restructuring, mergers, and acquisitions characterize the post-cold war industrial setting.

Once the military force has been reduced, the LCS industry may lose its critical capabilities and associated skills. This risk must be weighed as we look to future requirements for tracked vehicles. The costs associated with maintaining or losing these capabilities is significant but offset by potential savings in human and equipment survivability and, of course, victory rather than defeat on the future battlefield.

Tactical Wheeled Vehicles

Tactical wheeled vehicles support combat operations by transporting personnel, equipment, petroleum products, critical supply items, ammunition, food, and water. They also provide mobility for command, control, and communications systems and serve as platforms for weapon systems, such as cannon, machine guns and tube-launched optically tracked, wire-command link weapon (TOW) missiles.

Domestically produced tactical wheeled vehicles include a number of platforms that fall into three main categories, light, medium, and heavy, according to gross vehicle weight and carrying capacity. These categories include the following systems.

Light. The light, High-Mobility Multipurpose Wheeled Vehicle (HMMWV) currently in production at AM General Corporation at South Bend, Indiana.

Medium. The Family of Medium Tactical Vehicles (FMTV) in 2.5 and 5-ton versions produced by Stewart & Stevenson Corporation, Sealy, Texas. Another vehicle in this category is the Light Armored Vehicle (LAV) produced by General Motors, Canada in its London, Ontario plant.

Heavy. This category includes the Heavy Equipment Transporter, the Heavy Expanded Mobility Tactical Truck, the Palletized Load System, the Logistics Vehicle System, and a number of special-purpose vehicles currently in production at Oshkosh Truck Company, Oshkosh, Wisconsin.

The wheeled fleet of military tactical vehicles, unlike its commercial counterparts, must traverse terrain and distances similar to those encountered by "track" mounted combat forces. Travel must be accomplished at speeds to accommodate the full spectrum of the vehicles' combat missions in diverse and demanding climatic conditions—from arctic environments at sustained temperatures of minus 50°F to desert, off-road environments, such as those in the Middle East, with sustained temperatures as high as 130°F. In the past, survivability features were not as high a priority for tactical wheeled vehicles as for tracked vehicles, but the threat of land mines and other systems are changing this criterion. However, the design and survivability requirements for tactical wheeled vehicles are still less than they are for tracked vehicles. On the other hand, load capacity, off-road mobility, reliability, and simplicity of operation and maintenance are fundamental to supporting combat forces.

Tactical wheeled vehicles have more in common with commercial vehicles than do armored tracked vehicles. Their design is less likely to change with the changing nature of threats and is more amenable to using off-the-shelf components and production technologies developed for commercial vehicles. The latter can sometimes satisfy military requirements with little modification. Experience has shown, however, that even rugged commercial vehicles (for example, those designed for mining, construction, and other heavy applications) fall short of military performance requirements in most cases. This realization prevents complete transition to a "single process" in firms that try to meet commercial and military operations requirements.

CURRENT CONDITION

Currently, significant modernization efforts of infantry fighting vehicles and artillery systems are underway worldwide; simultaneously, more limited modernization of tank force performance and capability continues. Support and transport systems are also scheduled for modernization from cold war levels, although at a vastly reduced rate and over extended time lines. Overall, the world's land armies are modernizing their forces while net US LCS capability declines. Regional and transnational actors coupled with asymmetric force modernization and a complex array of possible scenarios are greatly increasing US risk of failure in the future employment of its land combat forces.

The US political environment remains oblivious to the reality of increasing uncertainty and growing risk. Defense procurements of new and modernized systems continues to decline, imperiling DoD-wide modernization efforts and forcing a fratricidal search for "bill payers" to fund more glamorous modernization efforts. Outyear funding for major programs remains predicated on base closures and acquisition reform strategies that have garnered scant support within Congress. Worldwide operational requirements, which are frequently inadequately funded, have captured the lion's share of total funds and threatened to disrupt even the modest improvement programs currently funded by DoD. It is increasingly apparent that the required economies needed to fund modernization will be generated by a further reduction in land forces in the near term.

The evolving competitive environment is characterized by the ongoing consolidation of producers and suppliers. Growing horizontal and vertical integration of firms coupled with government to industry

and firm-to-firm partnering arrangements are key elements in fostering a viable, competitive industry in a rapidly globalizing business environment. The majority of industry contractors continue to absorb high levels of overcapacity as they struggle to resize their industrial base to the reduced demand levels projected for the future. This problem is especially acute in the nation's GOCO and GOGO (government-owned, government-operated) facilities. Where possible, the substitution of commercial business for defense requirements has eased the transition but may lead to further erosion of firms committed to the defense industrial base.

The extensive globalization of the land combat equipment business has placed a premium on efficient, adaptable management practices and flexible-manufacturing systems in a vastly reduced number of horizontally/vertically integrated, world-class competitors. Similar reductions in GOCO and depot facilities are taking place as DoD struggles to find an appropriate mix of commercial and government facilities and capabilities. In summary, the LCS industry is collapsing to a viable, competitive, and efficient equilibrium in reaction to an uncertain government procurement environment. It remains to be seen which firms will survive this highly competitive, worldwide fight for survival.

Role of Government Requirements

The following observations describe the impact of government requirements on the combat vehicle industry.

- Unclear, underfunded requirements and uncertain future demand coupled with interservice budget battles have greatly increased uncertainty and risk for the remaining competitors in the LCS industry.
- Firms are unlikely to survive based on domestic requirements alone. A strong competitive position in the consolidated global market will determine which firms will lead the industry in the next century.
- Consolidation of the European LCV market and its extension beyond its traditional markets may ultimately generate a larger market segment than the US domestic LCV sales. Domestic producers will have to extend their reach into nontraditional markets or be relegated to the second tier of global producers.
- Current production and development efforts appear inadequate to sustain the current base of two major domestic tracked

vehicle producers. Without an increase in government demand, subsidy, or a major merger or partnership with a foreign competitor, the US may lose one of these firms in the next decades.

- GOCO and GOGO facilities are struggling to operate competitively despite the burden of considerable excess capacity and an inadequate cost and pricing structure. While there is clearly a place for these facilities, further restructuring and downsizing are required to reach an efficient and competitive structure for the next century.

- While it is prudent to maintain some overcapacity to meet unforeseen circumstances or to deal with a failed "come as you are" strategy the massive excess capacity in the industry is unsustainable. Further, it is mostly unusable in the present form with 18 to 24 months required to employ the idle equipment and production operations effectively. Significant efforts and DoD direction are needed to identify the mobilization base required and to structure it into a useable form.

- To economize, the US government is seeking joint venture partnerships for future vehicle development. This trend has positive and negative implications for the US. It is possible to contain costs, to broaden market opportunities for the final product and to ensure the survival of critical production facilities and skills. However, the risks associated with internationally shared R&D and foreign supply sources must be carefully weighed in each partnership venture.

- Continued consolidation of second and third tier suppliers is driving many inefficient, unreliable, and expensive producers out of the defense industry. It remains to be seen if the reduced volume and extended life of legacy systems are sufficient to sustain a viable vendor base for the LCS industry.

- Diminished defense requirements are driving many segments of the wheeled vehicle industry to shift the mix of their production (where possible) from defense to commercial goods. While this has increased their financial health, it may significantly weaken their link to the defense industry, eventually leading to their withdrawal from the industry. Sole defense producers may find it difficult to survive in this environment of reduced demand and uncertain future orders.

DoD continues to face the classic dilemma of achieving short-term efficiencies and cost savings without imperiling the future health of the

entire industry. The jury is undecided on which strategy will steer a course that successfully meets both requirements.

Industry Responses

In response to shrinking defense procurements and escalating global competition, the remaining contractors in LCS industries are exploring every possible strategy to cut costs, to improve their competitive posture, and to expand market share.

Redefining Core Competencies and Downsizing. Each of the remaining firms in the industry is carefully reconsidering its basic structure and core competencies. These deliberate reviews refocus management efforts and redefine the nature of the firm and its future strategic direction. It is interesting to note that of all the firms visited, none identified the same core competency as its unique contribution to the industry. This deliberate reinvention of the firm is already paying dividends through increased efficiencies in management, administration, and production operations. It has also served to guide the affected firms through another round of acquisitions and divestitures and further downsizing of production operations. With overcapacity running more than 50% across the industry, it is not surprising that extensive work force reductions continue. Among domestic manufacturers, reducing the workforce to a competitive level has created a highly skilled, but rapidly aging employee pool. Since current demand levels do not support the hiring and training of a new generation of workers, projections indicate the LCS industry may face a crisis of diminished critical skills and turnover of experienced workers within the next 20 years. This situation is not common overseas because either the government has mandated government employment levels or there is extensive cooperation between firms and the technical education system to develop an adequate supply of skilled future employees.

Consolidations, Mergers, Acquisitions, and Diversification. Current trends in this arena fall into three categories. First, many firms are seeking complementary product lines primarily to gain production efficiencies and to expand their market share. Second, the acquisition and integration of key suppliers from the vendor base targets increased efficiency of production, reduced costs, and increased profit margins. Third, a few business segments that no longer fit with the redefined core of specific firms have been divested. These divestitures have generated substantial funds that will continue to fuel near-term activity in this arena.

International Partners and Cooperative Ventures. Across the LCS industry, efforts are shifting from contraction and consolidation to a vigorous competition for a worldwide market share. Two strategies are emerging: international partners and cooperative ventures. Each is based on a traditional division of the international LCV market and targets either the European or American primary markets and their traditional, downstream client markets. Each strategy has engendered an ardent search for partners to provide access to nontraditional market segments or to consolidate and defend traditional LCV sales from outside competitors. It is unknown which strategy will facilitate the emergence of a dominant producer within the industry. It is also unclear whether international government intervention will further limit or restrict access to markets or subsidize domestic producers.

Research and Development. One final observation regarding the LCS industry is noteworthy. Increased uncertainty, reduced demand, and a greater risk burden borne by the industry is significantly inhibiting basic research. In most cases, industry development focuses on application R&D targeted to take proven technology to a higher level of performance. Given the current state of the industry, there is scant likelihood of achieving the revolutionary technological breakthroughs predicted for LCVs in the future without significant government sponsorship and investment in basic R&D. Additionally, industry is unwilling to bear the costs and risks.

Other Pressures

Excess industrial capacity and excessive overhead costs, and rightsizing of the GOCO, GOGO, and commercial base further constrain current operations in the LCS industry.

Excess Capacity and Associated Overhead Costs. Current US production facilities were built to mass-produce goods to meet large-scale production needs based on a cold war model. Our extensive remaining capacity either supports a mobilization surge capability or has proven politically impossible to close. However, current DoD policy does not recognize the requirement for surge capacity because future wars are projected to be of short duration. If that is the case, then the nation has an excess industrial capacity that is expensive and wasteful. Most facilities operate at 60% or less of their capacity and some are operating at only 10% of their potential. In facilities designed for high-volume assembly lines, small work forces are now producing individual vehicles and tanks.

Current manufacturers involved in defense-related production, such as LCVs, compete with military depots for business. Some of them operate government-owned facilities larger than required for operations that result in extensive overhead costs for these firms. These overcapacities in depots and GOCO facilities place domestic defense firms at a distinct competitive disadvantage. Excess capacity remains the single most important impediment to competitiveness in the industry, other than the declining defense budget itself.

Rightsizing the GOCO, GOGO, and Commercial Base. A corollary issue is what mix of facilities best meets America's competing goals of an efficient, cost-effective LCV industry while providing the requisite capabilities and depth to deal with the uncertain defense requirements of the future. Right now, the redundancy and high costs of today's facilities represent a cost burden the nation is increasingly unwilling to shoulder to procure its future LCV requirements. DoD must undertake a deliberate effort to rightsize government production facilities and depots consistent with the level of commercial vitality they seek to engender in the LCS industry.

CHALLENGES

Military budgets have been declining for 12 consecutive years. Predictions for outyear budgets in the Future Years Defense Plan (FYDP) barely keep pace with inflation. Without significant increases in acquisition dollars or further reductions in infrastructure and personnel end strength, the services' modernization plans are unrealistic and untenable. Currently, the only other viable potential source of funding is in the search for greater efficiencies through additional base closures.

America's ground forces have few land combat vehicles on the drawing board. The Army's Crusader and Grizzly and the Marine's Advanced Amphibious Assault Vehicle represent all new development. The remaining programs are modernization efforts of existing equipment that the land forces expect to keep for at least another 30 years. The net result will be a 50-year old armored fleet by the year 2025. With only 20% of the fleet scheduled for modernization, most of the vehicles will not have any technology insertion over the 50-year period. Some will mention systems, such as the B-52, as examples where modernization has been successful, but the B-52 has had multiple upgrades in electronics and other systems. DoD should not expect the 700 suppliers for the Abrams Tank, for example, to remain in business for another 30

years producing parts for a system that is already 20 years old. The challenge for the field forces will be finding the parts, dealing with the associated longer lead times, and being able to afford them. For example, in the electronics industry the technology currently turns over every 2 years, so 50 calendar years can represent 25 generations of technology.

Supplier Issues

There are only two American firms with sufficient capital investment to produce tracked combat vehicles: United Defense Limited Partnerships (UDLP) and General Dynamics Land Systems (GDLS). Both firms are operating significantly below capacity due to reduced government demand. If these two companies were to merge, there would be no domestic competition in the marketplace. The current situation reflects managed competition, where no one firm is likely to receive all the business opportunities. The government is making it clear that neither firm will be purposely forced out of business. At the same time, there is no attempt to fully utilize existing capacity. DoD's intent is to maintain the status quo through limited orders and antitrust threats.

Both UDLP and GDLS are categorized as system integrators who rely on a large second and third tier supplier base to provide the needed parts and equipment to produce their respective end items. Although the government will not force either major firm out of business, that same protection is not extended to the lower level supply firms. Consequently, suppliers of critical parts and key technical skills are vulnerable to extinction if there is insufficient business to sustain a profit margin. This will cause serious problems in the event of a protracted conflict. Once the existing supply of critical parts is exhausted, the time line to resurrect a cold production line (temporarily shut down) or to create a viable substitute is a minimum of 18 months. Officially, DoD does not predict a need for a surge capability in the near to midterm. However, during Operation Desert Storm, \$150 million in spare parts were taken off the M1A tank modernization line to fill requirements in the Gulf. Without a warm (up and running) modernization line, there is no production capability to satisfy this kind of requirement.

Regulatory Constraints

An important tenet of acquisition reform is that DoD must reduce its reliance on military specifications and standards; instead, changes in

military technology must follow the commercial world. As old technologies, parts, and processes are discarded and replaced in the marketplace, military organizations will have to revamp, retool, and reprocure to keep up. Dual-use technology is often proposed as the solution to the inefficiency of maintaining two distinct processes. However, there are limited opportunities to leverage commercial applications with military vehicle systems, particularly in the tracked wheel community.

A second issue associated with the acquisition challenge is the increasing reliance on firm-fixed-price-contracts to execute DoD's mission. The net effect of this contractual strategy is to transfer business risk from the government to the contractor. However, a performance-based requirement connected with a fixed price contract transfers all required R&D risk to the contractor. Within the tracked combat vehicle industry, this policy has created a conservative mind-set toward investments in new technology. This is a critical omission for an industry in serious decline. Without government support for continuing R&D into new technologies such as new armor materials or designs for lightweight vehicles, the LCS for Army After Next will not look much different from the systems in today's inventory. A more balanced approach toward contracting would allow the government to assume the early-on development risk that would ensure a more secure and relevant future for tracked combat vehicle systems.

The budget process with its emphasis on annual authorizations and appropriations complements the issue described above. Since production contracts typically run anywhere from 3 to 5 years for LCS, multiyear contracting is a technique used to generate program cost savings and achieve rational program planning. This is a procurement method used to commit the government to the acquisition of weapons systems requirements for up to 5 years, without having all funds for the entire multiyear period available at time of award. An advantage of this technique is that it allows the amortization of certain nonrecurring costs for the entire contract quantity resulting in level unit pricing for all items contracted. It also assures the contractor a steady stream of funding from annual appropriations for every year of the contract. This permits contractors, from the onset, to plan their production resources more efficiently. Multiyear contracting makes one very basic assumption—Congress and DoD will commit themselves to a program financially and managerially for up to 5 years. Typically, this has not been the case and results in tremendous uncertainty within the industry.

Another regulatory issue is the Buy America Act that restricts foreign competition for defense contracts. Some firms are having difficulty maintaining second and third tier supplier relationships within US borders. To develop competition and maintain best value, offshore suppliers must be allowed to compete.

International Industries and Markets

To ensure a basis for comparison with domestic industries, the study group evaluated several European manufacturers of land combat systems.

- Styer-Daimler-Puch, Vienna, Austria manufactures the 6-wheel-drive Pandur armored personnel carrier in several variants.
- Krauss-Maffei Wehrtechnik, Munich, Germany manufactures the Leopard II main battle tank for domestic and international forces.
- IVECO, Ulm, Germany manufactures trucks including civil and military variants.
- Giat Industries, Roanne, France manufactures the LeClerc main battle tank for both French and international forces.
- Royal Ordnance, Nottingham, England manufactures numerous artillery cannon, mortar and small arms for global distribution.
- Vickers Defense Systems, Newcastle, England produces the Challenger II main battle tank for British forces and is trying to enter the offshore market.

Most European manufacturers are systems integrators. As a government-controlled industry with a strong labor employment mandate, Giat is unique in considering vertical integration and may begin producing component parts. Unlike the US industry, European manufacturing processes are largely labor-intensive with little automation. Quality control is highly effective. The group did not observe the labor force-aging issues found in US industry. Overall, the Euro-industries are most differentiated from the US base in terms of their smaller scale and greater reliance on touch labor, where the majority of assembly is done by hand.

Regarding the domestic base, the present strategy of keeping two large systems integrators in the business, although at a very low level of production, means that neither company will be a robust competitor on the international market scene. This raises the possibility of a foreign competitor attempting a merger or some form of cooperative relationship

with one of these firms. Globally, too many companies are chasing fewer opportunities for foreign military sales. As the competition becomes more intense, US firms may not be well positioned to compete with their global counterparts. When combined with the lack of technical innovation discussed earlier, this market condition is a formula for extinction. Maintaining a competitive advantage in the international marketplace requires efficient manufacturing operations, continued commitment to future product development, and aggressive global marketing.

OUTLOOK

The Land Combat industrial base remains fragile after several years of budget cuts and downsizing. Domestic production continues to operate well below capacity. In many segments, the industry is maintaining production through a combination of new system procurements, system upgrades, and extended service programs.

Short-Term Outlook

Upgrade and extended service life programs are the primary source of production for the Land Combat industry. The upgrade of the M1A1 Abrams Main Battle Tank to the M1A2 and System Enhancement Program (SEP) configuration will keep the Lima, Ohio, Tank Plant operating through 2003. The Lima facility also will provide 465 Heavy Assault Bridges (HAB), which are based on the Abrams SEP chassis. Similarly, the upgrade of the M2 Bradley Fighting Vehicle to the M2A3 configuration and the M109 SP-Howitzer to the M109A6 Paladin configuration will sustain production at United Defense's Ground Systems Facility in York, Pennsylvania. However, this comes at great cost to the US Army (USA), as overhead costs will continue to increase as a result of insufficient production quantities at both facilities.

The USA's 2.5-ton FMTV and the USMC Logistics Vehicle System (LVS) programs reflect the emerging trend by DoD to extend vehicle life through technical insertion and overhaul programs. Currently, USA and USMC are reviewing extended service programs for the HMMWV, Medium Tactical Truck (USMC variant only) and 10-ton HEMMT. Original vehicle manufacturers view these programs as an opportunity to keep their production facilities operating at more efficient rates. In the area of new procurement, USA and USMC plan to procure additional quantities of HMMWV from AM General, FMTV from Stewart &

Stevenson, and HETS from Oshkosh that should assist them in keeping new production. AM General and Oshkosh have combined military production orders with commercial orders to help reduce overhead costs and provide more efficient production rates. One of the firms has been most successful in this area by reducing its defense base from 90 to 40% sales over the past 3 years. The other has been less successful in diversifying into the commercial sector with only 10% of its current sales to the commercial sector.

The industry continues aggressively to pursue international sales for its systems. Still, the market is saturated as a result of overselling by domestic manufacturers after Operation Desert Storm and increased global competitors, including former Soviet Pact countries and China. The expansion of the North American Treaty Organization (NATO) could provide new opportunities for US manufacturers as new members upgrade their systems to NATO standards. Greece and Turkey are also in the market for a new main battle tank and associated support vehicles.

As production requirements continue to shrink, the industry is exploring initiatives to maintain financial viability through fleet management and virtual prime vendor relationships. Industry analysts anticipate these initiatives will assist in retaining fleet readiness, while reducing operations and sustainment costs and logistics infrastructure. Under a pilot program to start next year, the M109 Howitzer fleet will be the first system to be logistically supported by a commercial firm.

Long-Term Outlook

The future of land combat systems remains ill defined. DoD and industry leaders are unwilling to predict requirements beyond the current FYDP. Future procurements of the Bradley Fighting Vehicle and the Abrams tank remain unprogrammed beyond FY2003. The only certain long-term procurements are the purchase of 824 Crusaders, 1,013 Advanced Amphibious Assault Vehicle and follow-on procurements of the FMTV. Incremental procurements of the Grizzly breacher, Heavy Assault Bridge, and Heavy Recovery Vehicle are planned during this period, but they do not represent the quantities necessary to maintain viable production rates at either General Dynamics or United Defense, LP. The industry will need to continue adopting flexible manufacturing technologies to produce small volumes of technically diverse systems at lower costs. Without additional procurement funding to support the Crusader and other LCV programs, the USA will need either to stretch out or to cancel planned procurements of one or two LCVs. Extended

service programs and fleet management initiatives will probably become a core business of the industry.

In the area of R&D, the USA had begun work with the British on a Future Scout Vehicle with a projected fielding date of 2010. However, the Army has suspended development of the Future Scout Vehicle, until it can better define future combat vehicle requirements under the Army After Next Structure. It is continuing research on advance materials, armaments systems, and power train subsystems to support a future lightweight, mobile, lethal combat system.

Future Surge Requirement Capacity and Main Vulnerability. The challenges faced by LCV manufacturers include a diminished threat, declining budgets worldwide, increased competition, excess capacity, limited production rates, aging workforce and increased product mix. With these challenges in mind, estimates on future surge requirement capacity have to be evaluated in two ways: either the plant's production line is currently up and running (warm) or the production line has been temporarily shut down (cold). Looking at LCV requirements through 2010, the possibility exists for a cold production line at one or all LCV manufacturers. LCV surge capability is currently estimated at 10 - 12 months for a warm production line and 18+ months for a cold line. Surge capacity will depend on where the requirements hit in relation to the manufacturers' shared production line assets. In reality, there is little chance of timely mobilization.

The study group's recommendation is to maintain the LCV manufacturer production line in a warm status, though quantities may be limited. This would accomplish several things: shorten the timeline for a surge requirement, allow continued replenishment of war reserve stocks, maintain the uniquely skilled LCV workforce, and allow for future commercial and Foreign Military Sales applications.

Continued replenishment of LCV War Reserve stocks is of utmost importance. During Operation Desert Storm, critical items for LCVs such as the Abrams rotary shock, vee packs (air filter for the Abrams engine) and plenum seals (for the Abrams air filtration system) had to be taken directly from the LCV manufacturer's production line. Even though the war reserve stocks for the M1 Abrams were funded more fully than any other system at the US Army Tank-Automotive Armament Command, all the needed reserves were not on hand. In the event of a prolonged conflict (or more than one Major Theater War), a cold LCV production line would be disastrous.

An additional area to be examined when considering surge capacity is the LCV depot repair capability. Depot repair facilities are designed

for overhauling vehicles, not for new systems production. If a surge requirement came up and the LCV manufacturer's production line either was cold, or had insufficient surge capacity, significant investment in facilities and people would be needed to establish additional production capability in the depots. An additional option to consider for keeping the LCV production lines warm, is to offload work from depots to LCV manufacturers to support the continuation of the LCV private industrial base.

The most significant challenge and the main vulnerability to the LCV sector are the supplier base and the crucial support agreements that exist with these subtier contractors. Because of reduced production rates and streamlined operations, suppliers are leaving the LCV sector in search of reliable commercial companies. There are more vendor partnerships and long-term supplier agreements to secure equipment and parts availability. A constrained subvendor base places higher risk on LCV manufacturers and jeopardizes future readiness.

Commercialization and Internationalization of the Industrial Base.

The overall reliability of our manufacturing base during times of future major conflicts is threatened or questionable for the following reasons. There is a significant decline in demand for LCVs in domestic and international markets and an increasing reliance on the commercial sector, some of the first tier Land Combat industries are aging, and there are continued pressures to internationalize business.

Remanufacturing, upgrading, and technical insertion programs for foreign owners of American manufactured systems such as tanks, artillery, and trucks will drive some American manufacturers to consider offshore operations to meet this potential international market. Domestic and foreign entities are exploring the virtues of international partnerships.

The possibility of gaining a competitive edge in the global market or cutting development costs by using internationally available technology motivates US firms to form partnerships and build long-term relationships with foreign counterparts. When "buy American" statutes are attached to procurement practices, partnerships are the only way foreign firms can enter US markets. The current production of M1 tanks in Egypt and proposals to produce American systems in Turkey and Greece, are early examples of this transition to offshore locations, as is the trend to rely on foreign resources and vendors that do not fall under US mobilization policies.

GOVERNMENT GOALS AND ROLE

"As the only buyer, the regulator of all market activities, the specifier of the goods to be purchased, the banker, and even the court of claims," government controls the shape of the land combat systems industrial infrastructure (Gansler, p. 24). Government shapes the defense industry by virtue of laws that control mergers and corporate acquisitions and government's deliberate intervention in these merger actions. Government also rigidly controls the issue of profit either through regulations or price negotiation. The combined influences of dramatic reductions in federal spending and a complex regulatory environment have caused a deliberate consolidation of the defense industry into a few first-tier corporate giants supported by hundreds of smaller, lower tier companies.

In crafting the 1998 Defense Authorizations Bill, the House Appropriations Committee singled out tactical vehicles as being significantly underfunded and recommended the following increases in spending over the President's proposed budget (see Table 1).

Table 1: 1998 Proposed Budget for Tactical Vehicles

Program	Army Requested	Recommended
Bradley Base Sustainment	\$125,591,000	\$240,591,000
Field Artillery Ammunition Support Vehicle (FAASV)	\$0	\$ 40,000,000
M113A3	\$ 20,244,000	\$ 28,644,000
M109A6 Paladin	\$ 18,706,000	\$ 74,706,000
Crusader development	\$324,380,000	\$324,380,000
Heavy Tactical Vehicles	\$0	\$ 5,000,000

A dominant theme is an inconsistent vision of the military force structure between the executive and the legislative bodies. This report has profound implications for the defense industrial complex. A consistent vision will allow industry and lower echelons of government to plan and program future activities in this area. Consensus regarding force structure will allow for a stable, long term acquisition plan and will provide the opportunity for the defense industrial base to adjust itself to efficient manufacturing levels.

Government Sponsorship of American Manufacturers

With regards to the LCS industry, the US government exercises a controlling function. Other than legislative efforts to manage corporate consolidation and ensure there remains at least the appearance of competition, government does not play a husbanding role. Given today's compressed defense industrial base, most government regulations are designed to restrict growth and avoid the emergence of a defense industrial monopoly. As a further complicating factor, weapon sales are intimately linked with international politics and are even more likely to suffer strict government oversight and control, much of which will be subtly relevant. As an element of the American industrial infrastructure, the defense industry is subject to all of the normal restrictions such as taxes, environmental compliance, equal opportunity employment, safety regulations, etc. that are often perceived as stifling to growth.

Given this complex operating environment, how can the US government best sponsor or support manufacturers to become more competitive in the world market? Assuming there is little, if any chance that government will team with the LCV industry to help market their goods beyond what government does for industry at large, government has the following avenues of support.

- Continued support for R&D by funding government research laboratories, giving tax incentives for industrial-sponsored research and relaxing restrictions on cooperative industrial research and development initiatives.
 - Tax incentives to train and educate employees.
 - Incentives to recapitalize plant property and incorporate robotics, automation, computer design and processing, and other advanced technologies into the production process.
- Political support to mediate between industry and organized labor to counter the looming problem of an aging skilled workforce.
- Given consolidation within the defense industry and service acquisition strategies, life cycle management may be appropriate in some cases to stabilize further the industry and reduce the service support infrastructure.
- Capitalize on US technology and automation by encouraging the sale of technologically tailored defense systems

throughout the world market as a replacement for flagging domestic sales to the government.

- Encourage exploitation of dual-use technology for commercial gain.

Acquisition Reform

Acquisition reform continues apace with ongoing initiatives, addressing every aspect of the commercial interface between government and industry. One reason for the continuance of high-energy efforts in the reform arena is that previous attempts have not yielded the beneficial results that were anticipated. The group's observation has been that reforms have resulted in a "mixed-bag" of positive and negative effects. Perhaps the cause of the unintended negative consequences is that the bulk of reform initiatives have been linear solutions to a very nonlinear problem. In the group's dialogue with industry, the discussion tended to focus on the systemic benefits that a holistic reform approach might engender. The central concern was that change must result in a genuine transformation of the commercial relationship between DoD and industry. The government must initiate change of this magnitude. Simply put, only the government can change the rules, regulations and laws that bound the nonlinear commercial relationship between government and industry.

A priori, the first critical challenge for government leaders in the legislative and executive branches is to impose a rational budget process that provides multiyear funding free from annual manipulation. This reform alone would stabilize programs, reduce contractor risk and uncertainty, and result in the greatest cost-savings. Annual budgeting, (and the changes associated with it), is the single most costly factor in defense programs. It inhibits rational long-term planning by defense contractors and dissuades further innovation. Failure to pursue vigorously this reform wastes the taxpayer's money and reduces our ability to field effective military forces.

CONCLUSION

The group's major observations regarding the LCS industry (tracked and wheeled vehicle sector) depict an industry trying to preserve business viability while coping with dwindling production orders, declining budgets, and a cumbersome monopsonistic relationship with the DoD.

Against this backdrop, the LCS industries and DoD have developed a number of creative strategies to cope with uncertainty. The long-term decline in DoD procurement dollars precipitated an industry response consistent with collapsing markets. Domestic and international manufacturers have been participants in horizontal integration via mergers and acquisitions, which resulted in a smaller number of larger globally-oriented firms. Similarly, to compensate for the loss of subtier vendor sources, for assemblies and piece-parts, many companies have responded by vertically integrating the production of these subcomponents into their own processes.

To maintain a warm production base and sustain ongoing business operations, industry is "fighting a holding action" animated by a three-pronged operational strategy. First, flexible manufacturing techniques have been developed to convert former new vehicle manufacturing lines into vehicle modernization lines. This action preserves plant capacity and a highly skilled work force. Second, innovative per unit cost reduction programs are aggressively pursued at every opportunity. A prime example is the Army's Enterprise agreement with UDLP literally to coproduce the Paladin artillery system. Another example is the USAR's "six-by" medium truck service life extension program with AM General, in which the government provides the input raw material of an unserviceable truck into one end of the process and receives a virtually new vehicle at the other. Third, industry is attempting to develop new business enterprises that capitalize on existent core competencies. The most promising venue is the expansion of contractor support for maintenance and repair, parts support, and training throughout the life cycle of the vehicle fleet. This concept fuses the technical, distributive, and production core capabilities in industry with similar DoD capacities to maximize the best of both worlds and enable low risk divestiture of excess DoD capacity.

On balance, the study group found an industry managing the stressful transition from a cold war growth posture to the complex realities of post-cold war frugality. The "holding action" has successfully preserved the LCV industrial base for the near term (current FYDP). However, the next budget cycle represents a pivotal decision point in the continuance of the US LCV industrial base. Without either a consensus for new vehicle manufacture or a robust modernization program of legacy fleets, the industry may not remain viable as a manufacturing capability.

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MUNITIONS

ABSTRACT

The Munitions Industrial Base (MIB) includes conventional munitions, precision guided munitions (PGMs), weapons of mass destruction (WMD), and munitions of the future. Each presents unique industrial challenges to our ability to supply the munitions needed to support the National Military Strategy. The issue for conventional munitions is the US' ability to replenish our stockpile in time for a second conflict. The study group believes that the conventional MIB is able to provide adequately for the Nation's needs although specific areas require attention. For PGMs, the government must monitor the consolidation of the industry to ensure continued American technological superiority and fair competition. For the nuclear component of WMD, the issue is whether the Department of Energy will be able to assure the reliability of the warhead stockpile. Munitions in developmental stages must be pursued to provide our war fighters the best munitions possible. Foreign sales of US munitions and potential offshore purchases of munitions or components must be a key aspect of our industrial policy.

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Force Base, AZ
Atlantic Research Corp., Gainesville, VA
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Lockheed Martin Vought Systems Co., Grand Prairie, TX
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INTRODUCTION

Munitions are at the very heart of warfare, just after the courage, training, and skill of the men and women who use them to defeat our enemies on the field of battle. This report describes the munitions industry by defining it and then discusses four of its components: conventional munitions, precision guided munitions (PGMs), weapons of mass destruction (WMDs), and developmental systems. It also discusses the role of the government and some international considerations.

There is an interesting paradox in the munitions industry. As our munitions and the related weapons systems that apply them purposely in armed conflict advance in sophistication and precision, their associated deterrent effect seems to increase. Just as the quantum leap in destructive power of nuclear weapons largely deterred powerful nation-state conflicts during the cold war, the range, accuracy, and standoff delivery of highly effective modern munitions may now usher in an era of efficient rogue state deterrence. The paradox is that the manufacture of some future "ultimate" munition may eliminate the need for most of the existing munitions industry capacity. For example, if lasers were to become effective individual weapons, how many ammunition manufacturers would be required? This pattern of developing industrial obsolescence has a long history in munitions and may never have an end point. Today, we are at another decisive point in the development of munitions. Like the cased cartridge and fuzed artillery shell at the time of the American Civil War or the atomic bomb at the end of World War II, we are about to bring a new generation of munitions to the battlefield. They will be "smart" or even "autonomous" and will have significant "standoff" capacity. As this new generation of munitions enters the battlefield, how much of the current munitions industrial base is required? The study group believes our industrial policy must consider the full spectrum of munitions and be future-oriented, accounting carefully for the impact of future munitions development and procurement on the munitions industrial base.

THE MUNITIONS INDUSTRY DEFINED

The munitions industrial base is an evolving entity that defies simple definition. For the purposes of this report, the munitions industry includes the companies and government facilities that produce every form of device that can be projected from a controlled platform or major weapons system to reach out and destroy or disable the enemy's capacity

to wage war. The traditional small arms ammunition manufacturers and producers of conventional bombs (up to 2,000 pounds), and casing manufacturers and explosive filling operations, are significant elements of the industrial base. Increasingly, however, the actual explosive or penetrating elements of a munition are less significant than the precision guidance, the hi-tech fuze, or the ultimate delivery platform. Thus, the critical components of modern munitions are the electronics, the optics, the Global Positioning System (GPS), the radar and laser guidance systems, the powered or glider delivery "truck," and the "smart" fuze or sensor. These manufacturers must be included in the industrial base. The "smart" guidance, delivery, and fuze kit packages that strap onto conventional "dumb" bombs make the conversion of traditional conventional munitions into precision weapons a vital industrial process. Weapons of mass destruction (WMD), which for all practical purposes under current US policy means only nuclear weapons, are an element of the munitions industrial base that is facing unique challenges. Finally, future munitions now under development (e.g., nonlethal weapons and directed energy weapons) might put explosive munitions in eclipse. While these future munitions are not in full-scale defense production, planning for their eventual procurement and employment requires that they be considered as part of the munitions industrial base.

CURRENT CONDITION

This section addresses the current condition of the munitions industry for the four distinct segments, conventional, precision guided munitions (PGMs), WMD, and munitions of the future.

Conventional Munitions

The area of munitions with the greatest volume of industrial output is the low-tech conventional munitions sector. This form of munitions is the staple of the ground soldier and the airman. It includes the ammunition that every infantryman's pistol, rifle and machine gun fires, the tank or tube artillery or ship's gun shell or the round for aircraft guns or shipboard air defense weapons, and the so-called dumb bomb.

The military's basic ammunition, commonly called a "round," has remained relatively unchanged since the introduction of the cased cartridge in the 1860s. The round has consisted of a metallic cartridge case (brass) with a primer insert, filled with a propellant charge, and fitted with a projectile (i.e., bullet). Sometimes, with larger rounds, the

propellant charges are in separate segments, bags, or cases and may be varied to change the range of the round. Until recently, conventional munitions changes have been evolutionary rather than revolutionary. As a result, there are currently sufficient manufacturers of this basic ammunition to meet our needs. However, trends since Operation Desert Storm are altering this position.

The Munitions Industrial Base Task Force estimates that a minimum of \$1.8 to \$2.1 billion in annual funding is necessary to sustain the industrial base for conventional ammunition. However, actual appropriated funding has consistently fallen at or below the \$1.8 billion level and even that level has been achieved only because of congressional additions to service budget requests. Profitability of companies in the ammunition sector is essentially at break-even levels, far below stockholder expectations in the current market environment. All of this presages further consolidation among producers of ammunition.

In the case of bombs, current demand is so low that the government relies on a single domestic source for bomb casings. There is some consideration being given to qualifying an additional source, but any such decision would be based on economic considerations to increase competition rather than based on the need for casings.

Looking to the future, the development of caseless conventional ammunition represents a revolutionary approach to munitions design. However, for the US to select, as an individual weapon, a rifle or machine gun that fires caseless or flechette rounds would demand a close examination of domestic production facilities and their capability to meet wartime requirements.

In peacetime, ammunition is not a national priority. "[Thus], if there is no ongoing government facility to take part in developing new ammunition by dealing with the production aspects of any proposed design, then there will not be any proposed designs, because the commercial market is unlikely to risk its own money on something that the government do not appear to want" (*Jane's Ammunition Handbook*, Foreword).

Precision Guided Munitions (PGMs)

Since the Vietnam conflict, our shot-to-kill ratios for bombs have shrunk from 1,000 to 1 to just under 3 to 1 at the time of Operation Desert Storm. The reason for this successful trend is the continuous improvement of PGMs. The ultimate goal of PGMs is to achieve a one shot, one kill ratio in warfare.

The attainment of this goal will require the use of what are commonly called smart weapons. Among the attributes that would define or characterize such weapons would be the capability of identifying (possible) threats/targets; determining what course of action to take when a target is identified (fire or not) and to aim, fire, and reload all on its own.

For our purposes, PGMs are a subset of smart weapons, encompassing the first two portions of the definition. Smart weapons use a form of artificial intelligence for their guidance and for their destructive deployment (target profile recognition by sensor and comparison to a memory of target signatures). The munitions industry has not fully developed a smart weapon. However, the PGMs' capability to distinguish between real targets and decoys, terrain, or clutter separates them from standard conventional munitions or dumb bombs. Although there is ongoing private and public sector R&D on the subject, most weapons in our inventories do not meet all the criteria for smart weapons.

Within the area of PGMs, activities include the conversion of dumb bombs to precision weapons, the development of munitions designed from conception as PGMS, and the exploration of offshore sources for PGMs.

Conversion of Conventional or Dumb Bombs. The US possesses many dumb munitions. Recently, DoD has actively pursued the conversion of dumb bombs into PGMs. The 500-pound bombs (MK-82) and the 2,000-pound bombs (MK-84) have been fitted with nose mounted guidance systems and aft wing extensions. This innovation transforms these dumb bombs into PGMs called the Guided Bomb Unit 12A/B and 10A/B respectively. The range of these weapons has been extended to 75 nautical miles when dropped from 40,000 feet. It takes only 30 minutes to install the guidance kit, using two bolts. This type of conversion improves the effectiveness of an otherwise limited use weapon, and its unit production cost is much lower than that of newer technology precision weapons (*Jane's International Defense Review*).

PGM Industrial Base. There is a variety of other PGMs in the inventory. The USAF munitions inventory is representative of DoD's pursuit of PGM employment to achieve a "one bomb, one kill" vision. Its PGMs include air-to-air missiles, air-to-ground missiles, and guided munitions. Facilities used to produce these weapons range from World War II era Army ammunition plants to modern, flexible, high-tech facilities such as the Air Force's Advanced Warhead Experimentation Facility (AWEF) at Eglin Air Force Base. For example, the AWEF provides state-of-the-art capability to conduct R&D of advanced warhead technologies including infrared and radar homing, heat seeking, inertial

guidance and data link updating, warheads, projectiles, penetrators, shaped charges, and heavy metals. These capabilities provide high kill probabilities for munitions with standoff capacities well beyond visual range. Besides the AWEF, DoD has extensive internal laboratory capability distributed among the services, including such facilities as the Dahlgren and Indian Head Divisions of the Naval Surface Warfare Center.

As the munitions industrial base modernizes, companies are employing a smaller, highly skilled workforce. Today's PGM industrial base employs a variety of sophisticated production technologies and methods to meet the demanding competitive technological environment. For example, the Navy requires insensitive munitions able to avoid sympathetic detonation. This effort requires the skills of chemists to understand and develop explosive compounds insensitive to shock emanating from the detonation of a nearby munition. The development of air delivered precision munitions requires a workforce skilled in laser radar, synthetic aperture radar, optical processor technologies, and GPS systems.

The base that supports air-delivered PGMs has undergone vertical integration—similar to the defense industry overall. A good example is Raytheon whose principal business is to design, manufacture, and service advanced electronic devices, equipment, and systems for both government and commercial customers. Raytheon purchased Texas Instrument's defense business assets to merge complementary businesses with no substantial product overlap. Raytheon also acquired Hughes Missile Systems, a company with which it shared significant product overlap.

Hughes and Raytheon developed the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM). Since both were successful with their prototypes, both received production contracts for the winning version. This strategy proved very successful for the government and gave each company a contract to produce between 600 and 700 missiles yearly. Until last year, the companies competed head-to-head with the winner receiving the major share of production. The missiles produced in Lot 1 cost approximately \$900,000 each. Eight years later Lot 9 missiles dropped to less than \$300,000 each. This reduction is even more significant when you consider that performance upgrades to the missile were being made every other year. In fact, the upgrades have so advanced the munition that the missile has undergone redesignation from AIM-120A to the far more capable AIM-120C.

However, the government's yearly missile requirement has fallen to a level that does not economically support two contractors. Raytheon

saw this as an opportunity and acquired Hughes Missile Systems Company with government approval. Even with this consolidation, the government's purchase of AIM-120Cs will be insufficient to keep Raytheon at full production. Although Raytheon's production line is capable of producing 80 missiles a month, the US buys less than 300 a year. Raytheon produces about 500 to 600 missiles a year for foreign governments that has helped keep unit costs down for the US and keeps Raytheon from losing money at present contract prices. If foreign sales decrease, it will be difficult for Raytheon to maintain its current price structure. The company has recently announced its intent to streamline defense operations. In 1998 and 1999, Raytheon will close or restructure 42 facilities and eliminate 9,700 jobs over the next 2 years (Muradian, p.16). All AMRAAM production work will be moved to the recently acquired Hughes facility in Tucson, Arizona.

Raytheon is a strong company, but sales opportunities in the US are diminishing. Some of its smaller subcontractors are affected by this diminished business opportunity. Their survival relies on providing piece parts for repair of older air-to-air missiles, but the total dollars involved are small. The government accomplishes its limited repair in military depot facilities rather than commercial plants. While Raytheon is still producing the AIM-9 for Foreign Military Sales (FMS), many countries are awaiting the development of newer models. The US has finished its procurement of the current AIM-9 and is developing the follow-on AIM-9X. It is anticipated that sales of the new AIM-9X will meet stiff overseas competition. The US market will not suffice to keep Raytheon a world leader in PGM production.

Another example of vertical integration in the defense munitions industry is Boeing's acquisition of Rockwell International's aerospace and defense operations in 1996 and its subsequent merger with McDonnell Douglas in 1997. Boeing is now a company that specializes in the design, development, production, and support of almost everything that flies, including PGM components. One more example of the vertical integration process that dominates segments of the PGM industry is the acquisition of Motorola's fuze business unit by Alliant TechSystems, an important munitions industry company.

Offshore PGM Sources. In America, business competition has reduced the number of air-to-air missile manufacturers to just Raytheon, but throughout the rest of the world there is a more complex marketplace with the potential to supply munitions that meet our needs. For instance, the US acquired the AGM-119B PENGUIN helicopter launched missile from the Royal Norwegian Navy. Using this method of acquisition (i.e., foreign sources), the US can save on R&D and production costs,

allowing those resources to be spent in other areas. In addition, US forces gain a proven and reliable system.

The United Kingdom, France, Israel, China, and Russia provide competitive systems. Germany is attempting to break the US monopoly on short-range air-to-air missiles. Germany has made a move to entice Canada, Greece, Italy, Norway, and Sweden to sign a Memorandum of Understanding in June 1998 to launch a project definition/development phase for a new short-range missile. Germany has high hopes that this consortium can sell more than 10,000 missiles in Europe alone (Shaw, p.4-9). Worldwide, competition is at an unprecedented level with many companies taking direct aim at Raytheon's market.

However, most foreign companies see the US as a relatively closed market and target other foreign countries for marketing. The issue for the US is a sovereignty issue and an economic issue. In times of war, countries want to be as self-sufficient as possible. To depend on offshore sources for the weapons of war would place us at the mercy of those sources and their governments. In addition, procuring munitions from foreign sources would be perceived as a threat to US jobs. Congress has been reluctant to appropriate funds when there would be such potential negative outcomes.

Weapons of Mass Destruction

Nuclear Component. At the outset, we must recognize that the nuclear weapons industry is largely the US government's laboratories and production facilities controlled by the Department of Energy (DOE). Private industry supplies a few commercially contracted parts, ranging from weapons components to management and analysis services. This is by far the exceptional circumstance rather than the rule.

The driving factor for the nuclear weapons industry in America is the end of the strategic nuclear standoff with the former Soviet Union during the cold war (DoD, 1997, Preface). Related to that fundamental paradigm shift is the package of interrelated international agreements (e.g., the Non-Proliferation Treaty, the Comprehensive Test Ban Treaty, START I, and START II) that limit and compel certain activities with respect to nuclear weapons. Also, one must never forget that nuclear weapons are unique objects. Even if their status as a weapon is defunct, each one is individually an environmental hazard of immense proportions and an immensely valuable source of illicit power if in the hands of evil-minded people. The US government has a significant moral obligation to sponsor an effective program of control over our nuclear weapons stockpile and

to assist with similar programs for those nuclear weapons of the nations of the former Soviet Union (*The Washington Times*, p. 13).

As noted above, our nuclear weapons are not merely static objects. The very term "radioactive" informs that a nuclear weapon does not sit on the shelf unchanged for years until needed. The engineering and technology to produce and assemble safely such a powerful weapon is dangerous and difficult. The industry does not have the capacity to "surge" or fast restart if such weapons are needed suddenly, but not in the inventory. However, the industry does have the ability to take the warhead package out of one form of nuclear weapon and reconfigure the ultimate delivery device to carry the "physics package" in another mode for a different mission.

So there is a highly complex engineering and technology process to be designed, evaluated, and then implemented in the nuclear weapons sustainment/maintenance industry. Our current inventory of nuclear weapons is tested and operable, but the new challenge is to maintain that status for much longer than originally anticipated.

As our nuclear weapons stockpile shrinks, it is vital that we can depend upon its operability. The restrictions on testing make new nuclear weapons development activities exceptionally expensive because of the computer simulation requirements that inadequately substitute for actual testing. DOE's Stockpile Sustainment Plan may be designed to perpetually fund a federal agency's role, and not to just maintain the nuclear weapons stockpile. To ensure reliability we should view our active inventory of nuclear weapons as classic designs. Through a program of remanufacturing and maintenance, they could be kept safely operable at a low cost—without the expenditure of exorbitant sums for computer simulation and new technology development by a federal agency.

Because the US' nuclear weapons industry is the government, it is also important that the sustainment and maintenance process be as simple and inexpensive as possible. Cost is a critical factor in the era of static defense budgets. The corollary is that simple is usually less expensive. At the present crossroads, the decision facing the government about nuclear weapons as munitions can be reduced to costs and results. Remanufacturing can provide the needed results at the lowest cost and sustain a viable US nuclear weapons capability and industrial base into the future.

Biological Component. In 1969, President Nixon formally changed the US policy concerning the development and use of biological weapons and agents. Following this action, by 1972, the entire US biological stockpile was totally destroyed. Although the US does not have

biological weapons, there are many countries throughout the world that possess or are suspected of having a biological warfare program. A key difficulty for combating these weapons is the realization that they can be produced in what is known as dual-use production facilities such as the infamous "baby milk" plant in Iraq. This reality is further complicated by the difficulty, if not impossibility, of detecting these weapons or agents. Although there is an antibiological weapons convention in place, there is no established method to enforce the conditions set forth in the convention. It is virtually an unverifiable program.

The US is a recognized leader in medical research and treatment. Regarding biological weapons, our medical laboratories and biotechnology firms are our munitions industrial base. As with many other issues requiring US government involvement, research, development, and intelligence are the keys to success in this area. The US must continue to employ its technology and information capabilities to detect or to identify possible threats. Furthermore, our nation needs to conduct an "assessment of the vulnerabilities of the US agricultural or ecological infrastructures to biological attack" so we can begin to devise appropriate response strategies and counterstrike munitions or defenses (Mayer, p. 8).

Chemical Component. "Although the United States has a large arsenal of chemical weapons, the United States has publicly stated its unwillingness to use these weapons of mass destruction" (Leyden, p. 1). The US currently possesses a large chemical weapons stockpile estimated at 30,000 metric tons of various lethal and nonlethal chemical agents. The commitment of the US, consistent with the Chemical Weapons Convention, to destroy its arsenal is demonstrated by Raytheon winning its third chemical destruction contract in 1997 for a total of \$1.6 billion. There are at least 16 countries making chemical weapons. Again, the key to survival and a strong national security policy will be the gathering of all types of intelligence and medical methods (antidotes) to counteract the effects of chemical agents. The development of munitions to facilitate the destruction of the chemical and biological weapons systems of our potential adversaries is also important. These actions are very similar to the ones discussed above for biological weapons.

CHALLENGES

For conventional munitions the major challenge will be to maintain an adequate industrial base, both in terms of capacity and technological quality to meet future demands for munitions. Cost control and the avoidance of technological obsolescence are the major challenges of the

precision guided munitions sector of this industry. Concerning WMD, two challenges predominate. First, can we be secure against attacks by chemical and biological weapons without the means to retaliate in kind. Secondly, will our nuclear weapon stockpile be sustainable or will the lack of active production cause a deficiency in technology and manufacturing skills that will hamper nuclear weapon activities in the future. For this future, the greatest challenge facing the munitions industry may be the need for several completely new categories of nonlethal munitions that require entirely new technologies and manufacturing capabilities.

OUTLOOK

The capacity for industrial production of conventional munitions, PGMs, and WMD in the US is shrinking and changing rapidly with technological developments and business consolidation. Further, external forces such as the military threat from potential adversaries, budget restraints, and treaty obligations limit it. The potential for conflict in a broad spectrum of intensity remains real and high. So, our munitions industry must remain future oriented, looking beyond current developments in guidance, fuzing, and delivery technology. Two new areas of growth are in nonlethal weapons (NLWs) and directed energy weapons (DEWs).

Nonlethal Weapons

With the end of the cold war and an increase in United Nations (UN) or multilateral peacekeeping operations, the US military is being increasingly used as a physical security force. With this transition has come a new challenge to US peacekeeping forces—finding an effective way to deal with crowds and mobs.

In early 1995, the UN Security Council called for the withdrawal of all UN peacekeepers from Somalia. The withdrawal, Operation United Shield, was executed by a combined task force commanded by Lieutenant General Anthony Zinni of the USMC. Based in part on previous experience, planners knew that unarmed, but hostile elements in Somalia could attempt to disrupt the withdrawal. Lieutenant General Zinni determined that NLWs were needed to help save lives and to minimize the impact of any possible confrontation. On an emergency basis, the Marines identified off-the-shelf NLWs and near-mature developmental NLWs that showed promise for being useful in this role. The main concerns were as follows: how well the individual devices

would perform in the Somali environment; how much time would be required to train individuals with no previous experience in their employment; and how NLWs could be fired from weapons already owned by a marine rifle company, specifically, the M203 grenade launcher, the M-16 rifle, and the 12-gauge shotgun.

The Marines quickly identified, located, tested, and obtained the appropriate devices with the support of many federal and local government agencies. These devices included nonlethal projectiles (beanbag, rubber-baton, and rubber-pellet rounds); stinger grenades (which dispense rubber pellets instead of metal shrapnel); sticky foam (dispensed by an operator against an individual human target); and barrier foam (resembles soapsuds, but laced with irritating gas) [DoD, 1996a, Chapter 12].

To institutionalize the NLW program, on July 9, 1996, DoD Directive 3000.3 was issued. It designated the Marine Corps commandant as the executive agent, established joint service organizational responsibilities, and provided guidelines for the development and employment of NLWs (DoD, 1996b). In January 1998, the NLW Executive Agent approved a Joint Concept for the development and application of NLWs. The Joint Concept provides guiding principles and identifies the required core capabilities associated with NLW technologies.

According to the NLW Directorate, the budgets for FY98 (\$17 million) and FY99 (\$23 million) seem adequate. The scope of current NLW research, development, test and evaluation (RDT&E) efforts is purely at the tactical level. Should the services redefine NLWs to include more strategic approaches (for example, use of informational warfare against enemy infrastructure), a budget of at least \$35 million a year would be required. This would also significantly enhance the fielding of current research projects.

Low-tech NLWs, already in use or in the process of deployment are mainly commercial off-the-shelf items used by law enforcement agencies. At this time, the high-tech items that are under R&D lack industrial manufacturers. However, the NLW Directorate hopes to recruit additional nontraditional DoD industrial activities for its R&D efforts.

In the last 2 years, the NLW Executive Agent has made significant progress in establishing an overall program for the development, acquisition, and deployment of NLWs. While there are still documents (such as Rules of Engagement) that require finalizing, the services are beginning to realize the importance of NLWs in their peacekeeping roles. However, it is time to start looking at NLWs' deployment more strategically. With the current "CNN factor" and the general public's

reluctance to accept casualties as a product of war, NLWs can be a viable tool and a reasonable alternative to lethal munitions in some potentially hostile situations (Joint Nonlethal Weapons Executive Agent, pp. 3,12, 18-20).

Directed Energy Weapons (DEWs)

It may be that *the* munition of the future is the laser. A laser is a device that produces a coherent beam of energy as light. The commercial sector has found many uses for the laser; it has the potential, at extremely high power levels, for military application. In the military, high power lasers fall under the category of DEWs. These weapons direct high power laser beams against targets.

Since a laser travels at light speed, compared to missiles that may travel at 1 to 3 times the speed of sound, a laser weapon would reach across thousands of miles in less time than a missile could travel a few feet. Once this beam hits the skin of a missile, or perhaps other soft targets, "...[i]n just seconds, [it] can slice through the metal skin...with the ease that a hot knife cuts through butter..." causing the object it hits to destruct (Jannery, p. 4).

Complex definitional and treaty compliance issues affect the role of DEWs. The fielding of such munitions may require the US to narrowly interpret the present Anti-Ballistic Missile (ABM) treaty. This treaty allows the US to pursue DEW technology by calling it purely defensive and intended only for theater level use. This option allows the US to attack the identified ballistic missile threat in theater level warfare and defend against attacks from rogue states. Also, the US can help secure its regional allies from short-range ballistic missile intimidation. This development process allows the US to maintain its competitive industrial advantage in laser technology for DEWs.

The Nation needs to enhance its efforts with respect to DEWs. We should continue the funding that is being spent on DEWs by each service, the national laboratories, and the Ballistic Missile Defense Organization. Since there is not an advocate for DEWs in the Pentagon, or elsewhere in the administration, a DEW executive agent should be appointed.

In addition, Dr. Jacques Gansler, Under Secretary of Defense for Acquisition and Technology, states that DoD should focus on dual-use concepts for our military systems, especially when developing new technologies. The DEW executive agent should have the additional mandate of focusing DEW development on technologies with dual-use potential. The dual-use concept potentially will allow commercial and

defense sectors to benefit from the money being spent in R&D and may allow some components of DEWs to be manufactured on commercial production lines. Such efforts tend to reduce the future cost of deploying, maintaining, and upgrading new munitions. An added benefit to this dual-use activity is that commercial firms may then work harder to maintain their competitive advantages (Gansler, p. 92). Gansler's premise is supported in Porter's *The Competitive Advantage of Nations*. He suggests that R&D, lower cost through productivity improvement, and product differentiation by quality and performance will provide the most significant competitive advantage in the future (Porter, p. 18).

GOVERNMENT GOALS AND ROLE

Whatever the future holds for the development of new forms of munitions in support of military operations, one can be certain that just as with all other categories of munitions, government policies and the role of government generally, will continue to be a major driver of the munitions industrial base. Federal government procurement, plant investment, munitions R&D, foreign sales policies, and strategic arms control policies will all be critical to the health of the industry. In the final analysis, the issues for the government relate to what, if anything, should be done relative to domestic munitions industrial base considerations and what is an appropriate policy toward foreign munitions sales.

Domestic Considerations

The government has many alternatives available regarding those companies involved in the munitions industry. Two alternatives that are of particular interest are whether to continue to encourage concentration of the industry into a few companies and whether to increase funding for munitions-related purchases. Both alternatives should be considered separately and in terms of economic consequences and financial performance. To address the consequences of government actions, the financial performance of a group of publicly held munitions industry companies was analyzed based on sales and dependence on defense sales. Although the analysis was not all-inclusive of the munitions industry, its conclusions are instructive.

Concentration of Munitions Industries. The government should carefully review acquisitions and mergers of munitions-related companies to ensure the resultant firm remains viable over the long term. If the government continues to support such concentration, the effect

would be to create larger companies that are more dependent on defense related purchases—because the new firm will have acquired a greater market share via merger. A decision to discourage acquisitions and mergers would result in no change in smaller firms' current dependence on defense-related purchases.

Overall, arguments in favor of acquisitions and mergers center on a larger company's opportunity to reduce duplicative overhead operations and to improve profitability. However, the group's financial analysis finds that the results do not support the argument. One conclusion of the analysis is that none of the representative group of companies analyzed currently meets commercial market standards for profitability. It is possible that the full effects of the latest round of acquisitions and mergers have not had time to result in a tangible change in performance. Thus, while the government should examine any munitions industry acquisition or merger on its own merits, it must review the effects of the latest round of acquisitions and mergers on long-term viability and profitability to determine the appropriate future course of action.

Most recent acquisitions and mergers of munitions companies have tended to be among companies that are already mainly dependent on defense-related purchases. For such munitions companies, absent credible evidence of improved efficiencies, there is little positive motivation for the government to support the creation of a still larger company almost wholly dependent on defense purchases. However, there may be a strong basis for government support in certain situations. For example, when two companies that are not significantly dependent upon the defense market become involved in an acquisition or merger, resulting in a company having an increased share of defense sales. The government should examine the resultant company's debt to equity ratio and other indicia of financial health to ensure that it can meet current obligations and borrow funds for capital investments. This financial analysis should show the potential to improve financial returns and lower overhead costs for the government, thus warranting government support.

Increased Funding of Munitions. The government can choose to increase its funding of munitions-related purchases with a specific interest in the health of the munitions industry. Alternatively, it can choose to keep munitions funding relatively constant and independent of the effects on the industrial base. The intent of a policy of increased munitions funding would be to attract companies to continue producing munitions. The attraction for the company is reduced risk, i.e., decisions are made with relative assurance that returns are available. The attraction for potential investors is less certain, however. Unless the additional funding results in improvements in management or capital investment

focused on improved profitability, the market will be inclined to put its capital funding into alternative investments offering higher rates of return. The potential exists for government subsidies to work against improved management of munitions-related companies. Absent the market imperative that forces decisions aimed at increasing rates of return, companies may tend to pursue strategies to preserve assured rates of return and to make capital investments in other areas where the market imperative is at work. As a result, funding beyond required levels may result in companies suboptimizing decisions affecting the munitions portion of their business.

Funding munitions procurement beyond requirements is an issue because it comes at the expense of other government-related purchases. To purchase munitions beyond what is truly required for national security needs means another area of government expenditures is reduced. Whether that additional dollar of government expenditure would have been for military pay, civilian health care, or a counterdrug program, the effect of funding one area of government expenditures beyond requirement is to suboptimize the overall federal budget.

Overall, there is no evidence that government funding of munitions in excess of the minimum required to support the national military strategy will result in a healthier munitions industry. Rather, it will result in companies increasingly dependent on this funding that are unable or unwilling to become competitive with the rest of industry.

Based on purely domestic considerations, government should be concerned about concentration of munitions-related companies into fewer and larger firms. The economic analysis tends to show this would result in larger companies whose improved financial performance has not yet been proven. In addition, the government should refrain from subsidizing these companies through additional funding. This serves only to reduce economic incentives to improve financial performance and comes at the cost of other needed government goods and services.

Foreign Sales

The US munitions industry needs to be successful in selling to foreign markets. However, the issue of arms exports via FMS or direct commercial sales (DCS) must be dealt with on a strategic rather than a situational basis, simply weighing political, economic, and social costs and benefits. This concept was recognized and approved by a noted defense business executive who commented that what companies sell abroad should not be decided by CEOs but as a matter of national policy.

But as a senior foreign policy advisor in the Bush administration pointed out, "The United States will rise or fall in the next 50 years on its ability to compete in international trade." Trade plays a key part in defining US political power. Thus, there is an inherent conflict between munitions industry marketing efforts and the US government's control over foreign munitions sales for policy, security, or technological reasons.

After World War II, arms exports became an instrument of policy, specifically a tool to help contain the spread of communism. Later, when fewer surplus weapons were available, arms exports shifted from donations to sales. In 1968, Congress enacted the Foreign Military Sales Act. The act attempted to limit military aid for purposes of internal security, self-defense, and participation in regional or UN arrangements. In 1976, Congress emphasized arms control rather than sales through its International Security Assistance and Arms Control Act.

In 1981, President Reagan announced a new policy on conventional weapons transfers. The policy emphasized not only the foreign policy benefits of arms sales, but declared that such sales were good for the economy by helping defense production capabilities and efficiency. Arms sales jumped up to \$13.4 billion in 1987. At the State Department, the Office of Munitions Control became the Center for Defense Trade. This subtle name change emphasized that selling munitions was the key policy goal— not controlling their existence.

In President Clinton's first year in office, with the end of the cold war, the defense industry found many new foreign partners. Foreign military sales reached a record \$33 billion in 1993. The present administration made explicit that a criterion for approving arms transfers was its impact on US industry and the defense industrial base. Sales of offensive, as opposed to defensive, weapons became possible.

The policy of containment has become one of strategic arms cooperation. An administration official responsible for international arms sales has stated that "the end of the cold war should not – need not – signal the beginning of a trade war in defense armaments. We can, and should, secure the benefits of military interoperability, along with the benefits of the world's best technology, from cooperation in defense armaments."

International Considerations

Internationally, governments and industry are reacting to the consolidation of defense industry in the US. They believe that the potential efficiencies to be gained within US industry because of

consolidation are a direct threat to their own industries' ability to compete on the world market and remain viable to meet their domestic needs. The nature of these varied nations' response in turn reflects innovative approaches to cooperation that cuts across national boundaries.

Issues of national sovereignty and varying forms of ownership will restrict, or at least slow, mergers and consolidation of companies across boundaries. In the interim, companies have chosen a different path to improve their competitiveness relative to US industry. That path, the multinational joint venture, works around sovereignty and ownership questions. One example of a joint venture that seems to be working is Matra BAE Dynamics (MBD). Formed as a joint venture of British Aerospace and the Lagardere Group, MBD is building cooperation from the bottom up by bringing groups of French and British weapons designers together to work. At the management level, the company deals individually with its customers, the French and British governments. Other joint venture arrangements are under consideration as representatives of government and industry overseas recognize that there are more munitions companies than the demand can support.

Over the long-term, we can expect that consolidation and mergers will occur among foreign companies, especially within Europe. The exact path, however, will depend in part on the European monetary union and the overall progress of the European Union (EU).

The interaction between governments and their munitions industries will be increasingly important in the next decade, as will the relationships between governments within Europe and between the US and Europe. New and better worldwide relationships between government and industry must emerge to allow for new cooperation and partnership agreements.

Competition

Cooperation has become the new strategy of competing for limited defense dollars. This will limit competition to groups of companies from varied national backgrounds competing against other similar groupings of companies. The stakes are high and in some areas single sources and monopoly situations may result. Surviving producers will be fewer in number but highly productive and much more efficient. Despite their reservations about the reliability of US industrial partners, UK, French, and German firms are looking increasingly toward joint ventures with US firms, although such ventures are not currently received with much enthusiasm in the US. This is primarily because of concerns about, and regulations restricting, industrial and weapons technology transfer.

US Strategy in Response

Although some EU countries consider the US government an unreliable partner, multinational cooperative agreements will remain a primary industrial strategy. While the globalization of the munitions industry appears to be a reality in today's defense environment, the ability to maintain an effective, safe, and affordable mix of munitions (high-tech versus low-tech) depends on sustaining in a global munitions market with allies and friends. The challenge for US government is to strike a balance in its technology transfer policies, the munitions industrial base's need to sell abroad for survival, and the US' national interest to protect domestic production capabilities, technological advantages, and unilateral flexibility in world affairs. The US needs a flexible munitions industrial base that can compete or cooperate, as appropriate, while taking advantage of technological advantages and efficiencies that result from domestic consolidation.

CONCLUSION

Several conclusions from this study are apparent. The future of munitions is in high technology applications. Classic ammunition and dumb bombs, the things that go "boom," are no longer the drivers. Precision guidance is today's preferred munition and even more precise guidance will continue for the future. Precision maneuvering to deliver these munitions will be available from delivery vehicles designed to keep the people who launch them out of harm's way. Fuzing that can sense types of targets or the depth of underground penetration and current surroundings before triggering detonation is an element of the future. The use of NLWs and DEWs that do not detonate at all are a part of the future. These developments come at a price and the ability or willingness to pay that high price will directly affect the munitions industrial base. Either a few giant defense companies will share the total available budget or companies able to master dual-use technologies will emerge to lower per unit cost of these systems. To the extent that remote guidance, sensing and delivery, and electro/mechanical actuating are the key technologies, it is reasonable to think that there may be some potential for such a beneficial result. Globally, business consolidation can be anticipated as foreign competition forces firms to merge, and world peace makes arms competition between superpower rivals less likely.

For the US, the munitions industrial base is shifting from conventional munitions to PGMs. Our reliance on PGMs means we stay

strong only while technology drives the development of munitions. The days of massive munitions purchases, go-to-war plans based on overwhelming conventional explosive force, or toe-to-toe ground combat with an equal adversary have passed. Our clear strategic and tactical advantage is in deploying the most technologically sophisticated package of munitions against a less developed foe. We must be able to kill precisely, from a long range, and to defend successfully—without suffering significant numbers of friendly casualties. These munitions will not be produced in large numbers and they don't have to be. The skillful use of these munitions by well-trained members of the armed forces, however, will be at a premium in this type of conflict scenario.

The consequences for the munitions industrial base over the next several decades are significant. We will need fewer end items and will require more producer guarantees of performance for "wooden" rounds. It will be critical that munitions are designed with improvements in mind and that engineering and manufacturing techniques can support future product improvements. Conventional explosive bombs may be obsolete shortly. Short-range artillery and tanks may become extinct. Soldiers on the ground, with their individual weapons, will always be critical to warfare, but their weapons may not fire bullets as we know them. Curiously, one significant potential variation in how changing munitions will affect the future of war is that industrial mobilization and the health of the national economy may play an even bigger part in generating and organizing logistics for successful warfare.

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SERVICES

ABSTRACT

The services industry is the largest and fastest growing segment of the US economy, comprising three-fourths of the gross domestic product. Service providers create value through nonphysical products, accomplishing tasks ranging from accounting and engineering to health care. As individuals seek higher quality lifestyles, personal services will proliferate. As organizations seek greater efficiencies through restructuring, downsizing and outsourcing, the industry will continue to grow. The challenge for business and government alike will be to focus on their core competencies while finding world-class service providers to perform peripheral functions. Because of the diversity within the industry, this paper focused on four areas: information technology services, consulting services, base operations, and logistics. Although the services industry faces many future challenges, it is clearly poised to play a commanding role in the rapidly changing US and global marketplace.

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PLACES VISITED

Domestic

Booz, Allen & Hamilton, Washington, D.C. area
British Embassy, Washington, D.C.
Brown & Root, Inc., Washington, D.C. area
CPCU Insurance, Washington, D.C. area
Defense Advanced Research Projects Agency (DARPA), Arlington, VA
Defense Logistics Agency, Ft. Belvoir, VA
Dyncorp, Ft. Rucker, AL
Edison Chouest Offshore, Washington, D.C. area
KPMG, Washington, D.C. area
Lear-Siegler Services, Washington, D.C. area
Logistics Management Institute, Mclean, VA
Naval Station San Diego Pierside Services, San Diego, CA
North Island Naval Air Station, San Diego, CA
SAIC, San Diego, CA
Space and Naval Warfare Systems Support Center, San Diego, CA
US Naval Base, San Diego, CA
USS CORONADO, San Diego, CA
USS KEY WEST, San Diego, CA
Westat, Washington, D.C. area

International

5th Signal Command, Mannheim, Germany
21st Theater Army Area Command, Kaiserslautern, Germany
NATO Maintenance and Supply Activity, Luxembourg, Germany
US Army Europe, Deputy Chief of Staff for Logistics, Heidelberg, Germany
Baltic Exchange, London, United Kingdom
"Flagship" Recruiting and Training Agency, Portsmouth, United Kingdom
Fleet Support Limited, United Kingdom
Lloyds, London, United Kingdom
Logistics Information Systems Agency (UK Army), Bicester, United Kingdom
Portsmouth Naval Base Command, Portsmouth, United Kingdom
RAF College, Cranwell, United Kingdom
RAF Maintenance Activity, Cranwell, United Kingdom
UK Ministry of Defence, Private/Public Partnership Unit, London, United Kingdom

INTRODUCTION

The services sector represents the largest, most diverse segment of the US economy. While estimates of the size of the sector vary, data from the US Bureau for Economic Analysis show that in 1996, sales of services accounted for 75% of the Gross Domestic Product (GDP). Employment in the services sector is estimated to be as high as 80% (Reich, 1992). Services are used extensively by individuals, businesses, and the government to accomplish tasks ranging from lawn care and accounting to engineering design for weapons systems. The rapid growth of the services sector is closely linked to several factors – the introduction of new technologies, corporate restructuring undertaken to respond to changes in the global economy, and government downsizing that forced civilian and military agencies to seek more efficient ways to operate.

Within private industry, firms recognized that they were performing functions in-house that would be more economical to contract out. The trend to contract out services or “outsource” spread rapidly as the efficiencies materialized. For example, rather than maintain expensive capabilities in market research or information management, many corporations eliminated these departments and bought the services from companies specializing in these areas. The practice of outsourcing has spawned a vast array of new service businesses that have emerged to take advantage of this trend, creating a symbiotic relationship between the service recipient and the service provider.

In response to budget cuts, the federal government has followed industry's lead in outsourcing many functions. Congress and the executive branch have supported government outsourcing through legislation and executive orders. By contracting for services previously performed by government employees, the US government has met its targets for downsizing, realized budget savings, and still maintained key functions. The military is the single largest consumer of contracted services in the federal government. Contractors manage military bases, conduct training, and provide combat related logistics support. As pressure to reduce the federal budget continues, more government functions will be contracted out to private service providers.

The services sector is a strategic asset for the US in that it accounts for a large portion of the economy and plays an increasingly important role in conducting government and military functions. This report examines the diverse nature of the services sector and the essential role it plays in the national economy. It also analyzes the scope of

government outsourcing, especially by the US military. Particular emphasis is placed on four key subsectors of the services industry: information technology services, consulting services, base operations, and logistics. Finally, the report identifies some of the challenges that will confront government and industry as they continue to explore new ways to accomplish essential services.

THE SERVICES INDUSTRY DEFINED

Basic Economic Sectors

Economic establishments create value for consumers either by producing a physical product (e.g., aircraft, tires, towels, wheat, etc.) or by offering a service (e.g., the corner gas station, Internet service provider, security services, parcel shippers, etc.). Both physical producers and service providers combine labor, knowledge, equipment, and/or material in bringing their output to market.

Physical Producers

Agriculture
Forestry
Fishing
Mining
Construction
Manufacturing

Service Providers

Transportation
Public Utilities
Wholesale/Retail Trade
Finance/Insurance/Real Estate
Services (e.g., health care, legal)
Public Administration

Service Activity within Physical Producers

Not all service activity is conducted by service establishments. Services functions are often performed organically by physical producers. For example, an automobile manufacturer may provide its own plant custodial services by hiring custodians as employees. Often, service functions such as general accounting, custodial services, facilities maintenance, and information systems management are performed organically in large corporations. Alternately, these functions can be performed for the physical producer by a service firm. Because of the mechanics of economic data collection, service functions performed within establishments classified as physical producers are reported in the sector of the company in question. If General Motors (GM) employees provide plant custodial services, the custodians are

reported as manufacturing employees; however, should GM contract out custodial services to a service firm, the custodians are reported in the service provider sector. Economic data likely underreports service activity while overstating physical production activity.

Size of the Services Sector

Of the two basic sectors, the service sector dominates in terms of output and employees. In 1996, service providers accounted for three-quarters of the national economic output and employed 80% of US workers (see Table 1). (These statistics are based on current reporting methods, which as previously noted, may be underreporting service sector activity.)

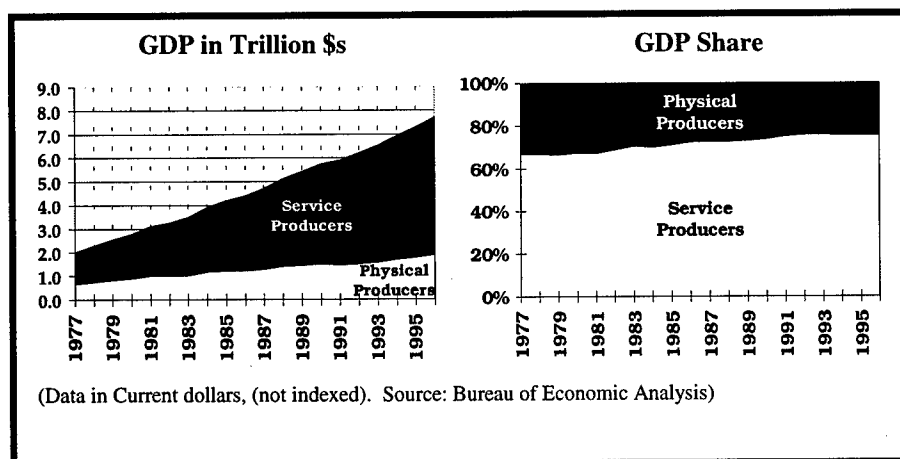
Table 1: Sector Output and Employees

Sector	Real Output (GDP, Billions)	Employees (Millions of Workers)
Services Producers	\$5,814	100.6
Physical Producers	\$1,882	26.9

Source: Bureau of Economic Analysis

The historical trend clearly shows that both services and physical production sectors are growing steadily. However, the services sector is growing at a faster rate than the rest of the economy (see Figure 1).

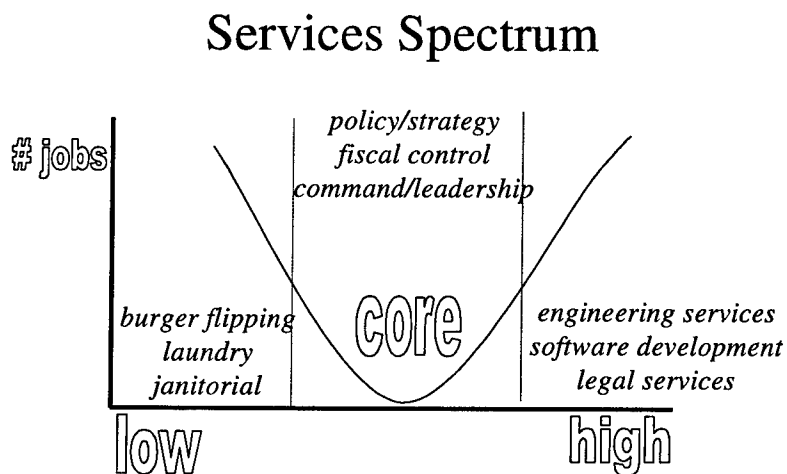
Figure 1. Sector Trends, 1977 to 1996



Services Spectrum

Figure 2 reflects the spectrum of services type jobs and the relative number of such jobs. Services cover a wide range of activities ranging from low-level, low-paying, labor-intensive jobs to high-end technical and professional jobs. Organizations tend to retain core functions such as policy and strategy, fiscal controls, and leadership positions. At the lower end of the spectrum, usually it is cheaper and more efficient to outsource the labor required to perform these tasks. For example, few organizations find that grass cutting is a core activity. At the higher end of the spectrum, it is often more effective to outsource specialized activities such as computer programming and legal services when this expertise is only needed sporadically or for a fixed duration.

Figure 2. Services Spectrum



As evidenced by the role of services in the overall economy, they are used extensively by industry and government. The primary focus of this industry study, however, has been the use of services by DoD.

Department of Defense (DoD) Service Functions Sector

Services activity is big business within DoD. The National Defense Panel estimated that DoD spends nearly 60% of its budget in the performance of service functions. In fiscal year 1997, the Department expended over one million work-years performing service functions — 853,000 work-years by DoD employees and another 207,000 by contractors (DoD, 1998). Only considering workers performing service functions, DoD would rank third in total employment in the US behind WalMart and GM (Taibl, 1997). The following reflects the major types of general services functions performed in support of DoD operations:

Social Services	Health Services
Education and Training	Base Maintenance
Installation Services	Intermediate Maintenance
Data Processing	Other (Non-Manufacturing)
Depot Maintenance & Repair	R & D Support
Real-Property Maintenance	

All these functions have equivalents in private industry. Accordingly, DoD is emphasizing “competitive sourcing” of these functions, subjecting more than 210,000 commercial activity positions to public/private competition from 1996 to 2003 (Cohen, 1997). Further, there may yet be room for expanding the list of DoD service activities that have private sector equivalents. Regardless, the predominant type of activities within DoD is service functions.

CURRENT CONDITIONS

There is a growing need for services. Households and firms are demanding more services and services of increasing quality and sophistication. The proliferation of services to support business and government is a natural adaptation to a requirement for greater efficiency and competition in both sectors. As competition has increased and markets have become increasingly global, efficient performance of service functions has become essential to managing costs and maintaining competitiveness. These trends are observed in much of the private and public sectors, both here and abroad.

Since the turn of this century, companies have been competing internationally in shipping, insurance, tourism, and many other service

industries. Still, nations differ markedly in their relative strengths in service industries, just as they do in manufacturing. Swiss firms are strong in banking, trading, logistics services, temporary help, security services, consulting, and training. British firms are influential in insurance, auctioneering, money management, and various types of consulting. Swedish firms specialize in shipping and environmental engineering. Singaporean firms are strong in ship repair, airlines, port and terminal services, and printing. American firms are leaders in hotel management, accounting, advertising, and a variety of other service industries. "As international competition in services grows and services become more sophisticated, national competitive advantage in services, or the lack of it, is assuming growing importance to firms and nations alike" (Porter, 1990).

Outsourcing Emphasis

Any current discussion of services leads to the subject of outsourcing. There is a whole spectrum of strategies that constitute outsourcing: contracting out, partnering, prime vendor, joint venture, employee stock ownership plans, and privatization to name a few. All have unique applications to the services sector, but are generically labeled as outsourcing strategies. The Defense Science Board defined outsourcing as "the transfer of support functions previously performed in-house to an outside service provider." Here, the service provider is usually given extensive flexibility regarding how it performs the outsourced function. Privatization is viewed as the most extreme kind of outsourcing where government assets, such as depots or data centers, are transferred to the private sector. Most DoD outsourcing initiatives do not involve privatization (Defense Science Board, 1996).

In business and government, organic service functions can be outsourced, that is, performed by people external to the organization via a contract agreement. However, outsourcing is not limited to service functions. End-item manufacturers regularly decide to stop building sub-components organically and acquire them from other, often very specialized manufacturers. Outsourcing generally results in improved focus, lower costs, often better subcomponents for the end-item manufacturer, and increased business and profit for the sub-manufacturer. Outsourcing therefore links the contracting company's competitiveness to the performance of domestic or global service providers.

The interest in outsourcing has shifted from cost containment and cost reduction to business growth and increasing market share. As more companies strive to be the best in their field, concentrate attention and resources on their core competencies, and move support activities to outside providers who can do them better or cheaper, outsourcing will grow. In many cases, even the threat of outsourcing can spur internal savings, improved performance, and increased productivity.

Because of the scope and overwhelming size of the services sector, this inaugural study effort was focused on four areas of concentration: information technology services, consulting services, base operations, and logistics. Each is examined below with a view toward outsourcing applications.

Information Technology Services

The information technology services sector is one of the most vibrant and fastest growing industry markets, accounting for \$379 billion in revenues in 1996 (EDS, 1998). Information technology has come to mean management information systems as well as telecommunications, and its scope is expanding. Information technology services are provided by a wide assortment of companies: those who own and operate data centers; those who use information technology to solve problems and perform business process engineering; and those who provide local and long distance telecommunications services. The US information technology service sector is the global leader and is poised to remain there.

Companies now provide information technology services as a complement to the sale of their products. This can be seen in telecommunication companies such as AT&T and Bell Atlantic that offer a wide range of services besides their core telephone service products. Similarly, Lucent Technologies and Nortel, the two largest telephone switch manufacturers, now offer a wide array of services to complement their core business lines.

The information technology sector popularized current business trends toward outsourcing. In the late 1980s and early 1990s, many companies determined that information technology was not one of their core competencies. These companies sought to buy capabilities from providers whose core competencies were indeed information technology services. Perhaps the most familiar example of this trend is General Motors, which selected EDS to perform its information technology functions. Information technology outsourcing is working so well that

sector growth has outstripped the supply of skilled information technology workers.

Business indicators reflect that the information technology service sector will continue to grow as more companies turn to outsourcing to keep up with technological advancement. Much of this growth is projected to apply to small and medium-sized companies that have not outsourced to the degree of their larger counterparts. These small and medium-sized companies are expected to turn to outsourcing information technology services as a means of staying competitive. Others are going beyond outsourcing, establishing strategic partnerships with information technology companies to give them access to specialized expertise in critical business functions. Most recently, corporate strategies embraced "virtual enterprises" that are dependent on effective information technology capabilities to allow staff reductions. The short history of the information technology services sector indicates it is a highly competitive industry that welcomes the opportunities for expansion.

Consulting Services

Within the fast-growing services sector, the consulting business has been one of its most phenomenal performers. Consultants, employed in both large and small firms, are hired for their unique experience, expert knowledge, or special ability to solve problems, and the ability to tap other corporate resources. The consulting sector includes management analysts and consultants hired to bring a particular expertise to bear on a client's issues. Their work varies with each client and from project to project, but overall, consultants collect, review, and analyze information, make recommendations to management, and sometimes assist in the implementation of their proposals.

The growth in consultant services in the 1990s is very much a result of evolving management practices and economic conditions. Commercial restructuring, increased business complexity, and the desire to penetrate global markets have caused the demand for consultant services to skyrocket. On the other hand, government has increased demand for consultants because of constrained federal spending and military downsizing. In 1995, US consulting firms employed at least 100,000 people full time around the world and have been growing at more than twice the rate of the world economy for the past decade. In 1994, they generated about \$11.4 billion in fees. By 1999, consulting services revenues will almost double to more than \$21 billion (Micklethwait and Wooldridge, 1996).

In fiscal year 1996, government agencies spent \$1.5 billion on consultant services, and of that, DoD contributed nearly one third (Laurent, 1998). The use of consulting services will increase as DoD continues to downsize.

Base Operations

Support of military base operations might be the richest target for the services industry that US government has to offer. Military bases represent significant investments in infrastructure, require a variety of service support functions, and have little to do with the deployed wartime identity of the units. These three considerations indicate the potential for outsourcing to provide the necessary services to the military units "home-based" at these installations.

Typical support functions include transportation, building and vehicle maintenance, provision of utilities, water treatment, waste disposal, police protection, and many other types of support. All these activities have private sector counterparts ready to take on a larger market share. In fact, DoD is actively learning lessons from state and local government initiatives in outsourcing basic services.

Taking advantage of the outsourcing experience recently gained by the city of Indianapolis could significantly shorten the DoD learning curve. In that city, Mayor Stephen Goldsmith applied the "Yellow Pages" rule. If any service performed by city government is advertised in the Yellow Pages, it is considered a good candidate for outsourcing. The city has saved more than \$80 million since undertaking the program in 1993 (Reinventing Government, 1998). These savings have been realized not only from outsourcing, but also from "forced" efficiencies within the government structure. For this reason, the city of Indianapolis is consistently held up as an example of how competition can foster greater efficiency and more effective provision of government services.

Using the competitive marketplace to bring efficiency to military base support is the key to bringing about the best value for base operations. In-house operations will be forced to trim management and infrastructure to compete with outside agencies. If they are unable to become more efficient, they are likely to be replaced or closed.

Logistics

Throughout the commercial and military communities, logistics management has become a significant focus of business strategies as

organizations attempt to "do more with less," increase flexibility, and generate savings. To produce more value with limited resources, organizations are reengineering processes, consolidating functions, and reducing infrastructure. This transformation affects logistics management as business leaders look for better ways to accomplish essential logistics services. The corporate world has become more competitive by transforming and outsourcing certain logistics functions. Much of the same is occurring in the DoD as the military services embrace the concept of "Focused Logistics" in pursuit of a system that is more responsive, flexible, and precise (Hallin, 1998).

DoD leaders today recognize that the private sector can perform many logistics functions at lower costs. In addition to outsourcing, the military departments are revamping many logistics services with initiatives such as prime vendor concepts and streamlined acquisition processes. Two logistics areas that reflect many of these new initiatives involve depot-level maintenance and flight line maintenance.

Depot-level Maintenance and Repair: Because depot-level maintenance and repair of major weapon systems is essential to peacetime readiness and wartime sustainment, the military services have traditionally preferred to possess robust, organic (in-house) depot maintenance capabilities. Secondly, DoD depot maintenance is an important element of the defense industrial base. Depot-level maintenance and repair comprises repair, overhaul, and modifications for items ranging from complete weapon systems to component parts. It also includes limited manufacture of parts, technical support, testing, and reclamation as well as software maintenance. As DoD strives for business efficiencies in the depot arena, there are a number of unique challenges facing both government leaders and private industry. These include, but are not limited to, establishing a free market concept of public/private competition, outlining potential risks in privatizing military depots, and dealing with legal constraints imposed by public law that restrict the amount of privatization.

As the government increased the portion of depot maintenance that private companies could perform, from 40% to 50%, the latitude for competitive sourcing also increased. In this environment, DoD's biggest challenge is to define and justify the joint logistics core competencies. An unexpected outcome of the depot consolidation and competition plan was the ability and desire of the public sector to compete for the available work leading to a system that now includes both private and public sector competitors. The overall push toward outsourcing has

introduced realistic competition and subsequently caused performance to improve.

Flight Line Maintenance: Over the past few years, DoD leaders have struggled to strike the right balance between organic and commercial flight line maintenance, the organizational level of maintenance for aircraft. In the past, government leaders have set limits on outsourcing flight line maintenance to prevent undercutting force readiness. Looking to the future, DoD leaders are considering a different organic-commercial operation-level balance to save critical resources.

Like DoD, the commercial aviation industry has changed the way it looks at aircraft maintenance. Some commercial carriers have achieved significant savings by outsourcing intermediate and depot level maintenance. However, they have not turned to service providers for handling basic flight line maintenance. The results are similar from an international perspective as US military allies hold onto organic capabilities and carefully weigh the risks associated with outsourcing select aircraft maintenance functions.

To reduce support costs, government leaders are turning over nondeployable flight line maintenance to a civilian workforce. On the other hand, in deployable units the military services have maintained a high percentage of organic aircraft maintenance capabilities due to concerns about wartime readiness. As seen in the Gulf War, however, a large number of DoD civilians and private contractors supported operations at or near the front lines (Hyde, 1991). Civilian specialists did not supplant organic maintainers, but instead, filled a critical maintenance need. Therefore, an all or nothing approach for either combat or non-combat support is no longer a realistic picture.

In the future, the government will face continued pressure to make logistics support more cost-effective. Commercial contracts will provide an important part of the logistics strategy as the military seeks to maintain readiness while taking prudent outsourcing risks.

CHALLENGES

As the dominant and growing sector of the economy, opportunities and impediments loom large for services. The challenges include: a shortage of skilled workers; leveraging technology; resistance to outsourcing; effective government control; defining core competencies; and contractors on the battlefield.

The Skilled Worker Shortage

One dark cloud hovering over the burgeoning services industry is the dearth of skilled personnel to perform the jobs in this expanding sector. The lack of qualified people is especially acute in highly technical areas such as information technology and engineering. At present the information technologies (IT) sector of the services industry is facing the most severe shortage of skilled workers available. This shortage has resulted in pirating of staff by competitors and recruiting abroad. The problem of worker shortage is not unique to the information technologies sector. There is a similar scramble for engineers and business school graduates by consulting firms. The challenge of recruiting is only part of the task. Retaining employees is difficult in the present competitive environment, where high pay and easy entry into the consulting business is the norm.

Leveraging Technology

The world is changing fast and the good providers today will not be the preferred providers of tomorrow unless they stay ahead of the wave. Today's leaders in the services industries are the best at applying technology to provide innovative solutions and unique capabilities. Leading edge companies who use the latest technology to provide "integrated solutions" will be the customers' preferred providers. A good example is a retail business with systems and processes providing linked inventory stocking, store sales, ordering, distribution, and accounting. Service providers must constantly upgrade their own technological capacity to provide the most advanced services to their customers. By leveraging the advantages that technology provides, service providers can maintain their competitive edge.

Government Resistance to Outsourcing Service Functions

The movement to contract out certain government functions is taking on the characteristics of an irresistible force. Notwithstanding the promised increased efficiencies and savings, there is considerable resistance to this new approach to government. The resistance is coming from different quarters: Congressional antioutsourcing caucuses, government labor unions, and military commanders. Yet, the mandate to inject more commercial providers into government activities and

budgetary constraints will inevitably bring along even the most recalcitrant bureaucrat or commander.

Effective Government Control

If government does not need to perform many service functions, it still must find ways to control and ensure satisfactory performance. The first step in ensuring performance is to begin with adequately defined requirements. Then, the government must require the highest standards of performance and accountability and should exercise its right to terminate or modify the contract when appropriate.

Defining Core Competencies

Before deciding whether to contract out any of its activities, the first task facing an agency is to identify its core functions. Generally, core competencies are an agency's reason for existing. For DoD, most of these functions are regarded as inherently governmental and are thus "so intimately related to the public interest as to mandate performance by Federal employees (OMB, 1996)." To stay competitive, business and government leaders must have the courage to make the tough calls about what their core competencies are and focus their resources on those areas.

Contractors on the Battlefield (COTB)

The military departments have attempted broadly to define core competencies as combat and combat support functions that must deploy, together with a core sustaining infrastructure to ensure readiness projection to the battlefield. Most commanders prefer military personnel because of the flexibility offered by their presence in a fluid environment. Besides flexibility, commanders are concerned with the level of commitment that the civilian contractor may have for the mission. Most commanders want to know: will they be there when the shooting starts? This has been an issue for 200 years. History and anecdotal evidence indicate that this apprehension is largely unfounded and can be properly managed. Because contractors will be on the battlefield, the issue will be how far forward should they go. Today's military operations do not always have clearly defined lines of battle and contractors will be integrated throughout the theater of operations. The

best way to meet the challenge is to promote military and civilian integration through training and education.

OUTLOOK

There appear to be two trends occurring simultaneously which are affecting the services industry in America. First, there has been the transition in the latter half of the 20th century from an industrial to an information-based economy in which services derived from specialized knowledge have more value than manufactured goods. This trend has accelerated in the last decade as innovative technologies in the information, communications, and biotechnology fields have created a myriad of new business and employment opportunities. Most of these businesses sell high-value services or expert knowledge packaged to meet the specialized needs of a customer. The outlook for the introduction of more advanced technologies is extremely favorable. We can expect that the services industry will grow as new products are developed and markets are identified. Given the increasing complexity and uncertainty found in the global business environment, service businesses that effectively use new technologies to help industry and government solve problems will come out ahead.

As we have seen, the second major trend that has contributed to the growth of the services sector is the massive outsourcing being undertaken by large companies and the government at all levels. However, this represents illusory growth of the services sector as such outsourcing replaces in-house operations not before recognized as services. Nonetheless, as the private sector and government seek to focus on core functions and contract out peripheral activities, a host of service providers has sprung up to take advantage of the new business opportunities. Thus, a change in the way industry and the government conduct business has directly contributed to the growth of the services sector. We expect this trend to intensify. As medium and small-sized businesses turn to outsourcing to increase their productivity and efficiency, we can expect the services industry to expand to meet this new demand. Remaining competitive in the global economy will require that businesses of all sizes identify and focus on their core competencies. Noncore activities will increasingly be accomplished by outside service providers who will thrive in an environment that values innovation, interdependence, flexibility and best business practices.

Federal Government Direction

Within the federal government, the pressure to outsource activities will continue unabated. Leaner budgets dictate that government managers seek new ways to achieve cost and operational efficiencies. Already, the push for outsourcing has introduced realistic competition into the government environment and caused improved government and contractor employee performance. There are significant opportunities for additional outsourcing by civilian and military agencies. Examples of additional types of functions that could be outsourced include entire DoD installations management, legal and medical services, education and training, finance and accounting, and information systems.

Some resistance to greater use of contracted services is expected from government agencies and Congress. Still, with additional federal budget cuts likely in coming years and the desire on the part of many to reduce the size of government, the need to find greater efficiencies through outsourcing is inevitable. This trend will offer substantial opportunities to businesses in the services sector. It is conceivable that in the not-too-distant future many functions now considered as governmental will be performed by private sector service providers.

International Direction

The international outlook for the services industry indicates continued growth and diversification. Industries and governments in Europe and Asia are beginning a process of restructuring and downsizing that should result in business opportunities for service providers. Contractors are recognized for being better able to add and delete services much easier and quicker than government organizations.

In Great Britain, the government has undertaken an ambitious program to outsource and privatize many of its defense functions under the national policy label of "contractorisation." How far this should go is being debated healthily by the British. Since the bold start of this initiative, the thrust has moderated to include partnering, private finance, and public/private competition. Recent British efforts to use private contractors to restore the legitimate government in Sierra Leone caused the Parliament and media to question "why even war is being privatised" (Segal, 1998).

Changes in the way American and multinational companies conduct their businesses have already created business opportunities for service providers in Asia. For example, companies in India are providing

programming and other computer services to international firms eager to take advantage of India's skilled workforce and low wages. With the arrival of almost instantaneous communications and information systems, the services industry has become truly global in nature.

Some governments have been slower to privatize and outsource. France and China have been notably less active in this regard, owing perhaps to a different philosophy of what makes up a government's core competencies.

GOVERNMENT GOALS AND ROLE

By the 1950s the US federal government had grown in size, and expanded the scope and breadth of its operations to a level that would have astounded the founders of our nation. Government had become big and inefficient, bloated by functions that had nothing to do with governing and everything to do with routine business activity. The services industry, with so much to offer in experience, pricing, efficiency and flexibility did not yet provide significant support for government officials.

In 1955 President Eisenhower declared that "the federal Government will not start or carry out any commercial activity or provide a service for its own use if such product or service can be procured from private enterprise through ordinary business channels" (Rehfuss, 1989). Not until promulgation of the Office of Management and Budget's Circular A-76 in 1967, however, was the policy applied on a government-wide basis.

Within the federal government, DoD has been a leader in efforts to outsource and privatize functions that either are not inherently governmental in nature or are not core military competencies. The Departments of Transportation and Commerce and the General Services Administration have also been active in outsourcing, but DoD has outdistanced the other agencies by a clear margin. Meanwhile, the smaller government agencies have been active in outsourcing functions, but they have virtually ignored A-76 guidelines for doing so (Thomas, 1998). DoD's success was due largely to two factors. As the largest agency in government with the heftiest discretionary budget, DoD is an attractive target for congressional budget slashers and of all federal agencies, only DoD was allowed to retain savings that were traceable to A-76 measures.

The federal government is paying increasing attention to the impressive efforts that state and local governments have made to

privatize and outsource their operations. In 1996, the General Accounting Office undertook an exhaustive study of several state and local initiatives. Common threads connected these program initiatives, but most of them chose to avoid the pitfalls of legislating or reducing budgets to force change, concentrating instead on increasing incentives for managers and workers to restructure government willingly.

At present, Congress is considering new legislation to reinforce A-76 and commit it to law. While private sector business groups view this initiative as a small but significant step in the right direction, many government employee groups see it as a thinly-veiled effort to deny them the right to compete for contracts.

The federal government has set a course toward increased competition for performance of its nongovernmental functions, to include both public and private sector players. For the foreseeable future, the lines between the two sectors will continue to fade, with greater use of partnering, franchising, and other mechanisms that will leverage competitive efficiencies and blend the strengths of industry and government supporting US national objectives.

CONCLUSION

Services have become a strategic element of national economic development and growth. Service industry providers create value and increase productivity. They specialize in doing things at world class levels, which in the competitive global economy, is often the leveraging factor that determines the efficient from the inefficient producers. Services represent a substantial share of employment and economic output in most all nations, especially advanced ones. With new technologies creating business opportunities as well as lifestyle changes, the services industry will expand into areas yet unimagined. As businesses and governments seek innovative ways to be more efficient and competitive, the services industry will become an even more vital part of the economy.

Services are often sold to other producers through outsourcing. Organizations are redefining their core competencies and shifting noncore activities to specialized companies that have figured out the best ways to accomplish tasks. While outsourcing has been around a long time and currently enjoys almost faddish management popularity, it is expanding to include partnering, joint ventures, private finance initiatives and other competitive sourcing strategies.

Many of the restructuring, downsizing, and outsourcing initiatives applicable to the business world are also relevant to government. In a number of areas, maintaining governmental in-house capabilities is not the most efficient way to provide cost-effective services for the taxpayer. As a result, governments are expanding the use of service providers in many traditional in-house activities to include information technology services, base/city operations, consulting, and logistics services. The difficult and unique challenge for government, particularly military organizations, is to incorporate smart business practices without jeopardizing national security. Although finding ways to reduce costs is important for government, it is different from pursuing corporate profits. Government leaders must balance the application of business efficiencies against national security needs and never let the scale tip in favor of the former. Government can emulate improved business operations when practical, and the use of world-class service providers will be a key ingredient for future success.

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SHIPBUILDING

ABSTRACT

US shipbuilders are without peer in their ability to produce the world's best military ships. To maintain the best Navy in the world, the America must sustain the indigenous capability to continue building these warships. Currently, the Major Shipbuilding Base can provide the nation with the navy ships it needs. Conversely, the US large commercial shipbuilders continue to struggle in reentering the large ship construction market. The study group found that the military and commercial segments of the market are quite different and that a successful *large* commercial shipbuilding industry is not fundamental to maintaining the naval capabilities essential to national security. An issue is whether the government should award construction contracts without regard to the effect on those shipyards building the nation's naval vessels. This study examined government's role in maintaining an economically viable, nonmilitary shipbuilding industry and provides policy recommendations, including approval of the OECD shipbuilding agreement.

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PLACES VISITED

Domestic

Alabama Shipyard/Atlantic Marine, Mobile, AL
Avondale Shipyards, New Orleans, LA
Bollinger Shipyards, Lockport, LA
Carderock Division, Naval Surface Warfare Center, MD
Central Gulf Lines, New Orleans, LA
Halter Marine Group, Gulfport, MS
Ingalls Shipbuilding, Pascagoula, MS
Newport News Shipyard, Newport News, VA
Supervisor of Shipbuilding: New Orleans, LA; Pascagoula, MS;
and Newport News, VA
Textron Marine and Land Systems, New Orleans, LA
USCG Activity, Baltimore, MD

International

Association of Danish Shipbuilders, Copenhagen, Denmark
Danish Shipowners Association, Copenhagen, Denmark and The
Netherlands
Ministry of Business and Industry, Copenhagen, Denmark
Odense Steel (Lindo Shipyard), Odense, Denmark
Blohm & Voss AG, Hamburg, Germany
German Shipbuilders Association, Hamburg, Germany
Kvaerner Warnow Werft, GMBH, Rostock, Germany
Meyer Werft, Papenburg, Germany
P&O Ned Lloyd Shipping, Rotterdam, The Netherlands
Van Der Giessen de Nord Shipyard, Rotterdam, The
Netherlands
Kvaerner Shipbuilding Operating Office, London, United
Kingdom
Joint Program Office, "Horizon" Tri-National Frigate
Project, London, United Kingdom
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INTRODUCTION

Since colonial times, the US has always been a maritime nation with a domestic shipbuilding industry. By the mid-1800s abundant lumber and naval stores enabled the US to become the premier shipbuilder in the world. A large commercial fleet and a superior navy contributed to the rise of the US as a global economic and military power.

In recent years, however, the US shipbuilding industry has declined. While still able to produce exceptional naval ships and smaller commercial vessels for domestic operations, the industry has struggled in the global competition for large commercial ship construction. Between 1987 and 1993, the industry sold only eight commercial ships over 1,000 gross tons, compared to 77 ships annually in 1975. According to the Maritime Administration (MARAD) [1997a], at the close of 1996, the US ranked ninth in the world among shipbuilders, with 1.8% of the gross tonnage in the world orderbook (number of ships contracted or under construction). This is the US' best ranking in years, but it is overstated by four petroleum tankers that Newport News Shipbuilding canceled in the spring of 1998.

This paper documents the results of a 5-month study of US shipbuilding by students of the Industrial College of the Armed Forces. The study focused on the industry's current condition, challenges and outlook, and the goals and role of the US government. The study methodology consisted of a literature review, analysis of presentations by industry and government experts, and visits to major shipyards in the US and Western Europe. The study includes a variety of policy recommendations aimed at promoting a profitable and competitive domestic, naval shipbuilding industry and identifies measures to improve American competitiveness in commercial ship construction.

This study deals with naval and large ship, commercial shipbuilding — two different but related areas. Regarding naval construction, there are two key policy questions that Congress and DoD must answer. How large a navy is the nation willing to afford? Will the Navy award construction contracts without regard to the impacts on the six major naval shipbuilders (the "Big Six")?

The study then explores the dynamics between commercial and naval shipbuilding and answers the question of whether or not that capability is needed to support naval shipbuilding and therefore vital US national security.

THE SHIPBUILDING INDUSTRY DEFINED

The US shipbuilding industry is comprised of facilities performing construction, conversion, and repair of government and commercial ships, barges, watercraft, and offshore oil platforms. US shipyards are either privately owned or government owned, and are divided by their maximum production capabilities and type of work performed.

MARAD surveys private yards to define the "Major Shipbuilding Base (MSB)." The MSB yards have at least one building and launching facility for vessels of 122 meters (400 ft) length and greater. By this classification, there were 18 active shipyards at the end of 1997 (see Table 1). According to MARAD, MSB yards employ 65% of the shipbuilding workforce with the remaining 35% working in smaller yards or support facilities.

Table 1: Major US Shipbuilding Base

Alabama Shipyard, Inc. AMFELS, Inc. Avondale Industries* Bath Iron Works* Baltimore Marine Industries, Inc. Electric Boat Corp.* Fraser Shipyards, Inc. Gunderson, Inc Halter Marine Group	Ingalls Shipbuilding, Inc.* Intermarine USA Marinette Marine Corp. Metro Machine Corp. Newport News Shipbuilding* National Steel Shipbuilding Co.* Portland Ship Yard Tampa Bay Shipbuilding and Repair Todd Pacific Shipyard Corp. <i>* The "Big Six"</i>
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Non-MSB yards generally construct smaller vessels (less than 122 meters) for inland and coastal waterways including workboats, tugs, fishing vessels, ferries, barges, and small military craft for the USN and USCG. Recently, the boom in offshore oil production led shipyards of all sizes into the market for producing Offshore Supply Vessels (OSV), although the MSB yards are now building the largest and most complicated of these vessels.

The Big Six yards build and repair the Navy's aircraft carriers, submarines, combatant, sealift, and combat logistics ships. These yards could produce large commercial ships such as oil tankers, container ships, bulk cargo carriers and, more specifically, the vessels involved in the Alaskan oil trade. Together, they also comprise six of the 18 MSB yards.

MARAD and the Navy also informally classify shipyards by tier. First tier yards are generally considered to include the Big Six shipyards, although some use first tier to include other builders of large ocean-going ships (e.g., Alabama Shipyard).

Second tier yards produce smaller vessels and repair naval and commercial vessels. Occasionally, the term "third tier" or subtier is applied to component suppliers. The unique requirements of nuclear propulsion related work requires specialized facilities and workers at all tier levels. Besides the commercially-owned yards, there are five government-owned and operated shipyards in the US and one overseas that perform repair work on Navy and Coast Guard ships. Three of these would meet MSB criteria if privately operated.

The US government remains the primary customer in the MSB shipyards, a trend that has been continuing since 1981, when US construction differential subsidies were discontinued. There has been some renewed interest by the MSB in producing commercial tankers due to the Gulf oil boom and the Oil Pollution Act of 1990 (OPA 90) requiring double hulled tankers for the US trade.

CURRENT CONDITION

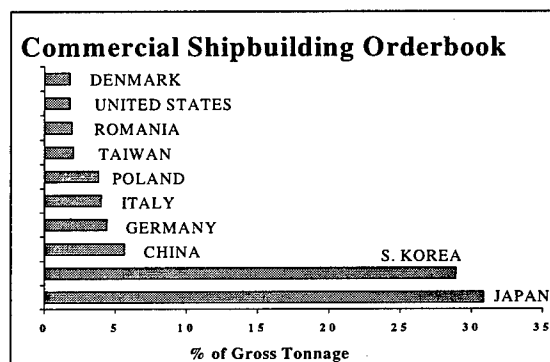
Asia and Europe dominate commercial shipbuilding. The Asian yards specialize in large, low technology crude and bulk cargo carriers, container ships, and car carriers. The European yards build higher technology container ships, ferries, cruise ships, and ships of special design. The US shipyards build technologically advanced naval vessels and small domestic trade ships, but do not compete in the global commercial market to any significant degree. Currently, the US shipbuilding industry fully supports US national defense and domestic requirements. Though the US government, like those of other nations, supports its shipbuilding industry with financial incentives and protectionist measures, it does so to a significantly lesser extent.

Global Trends

Although the global demand for new ships dropped from 1995 to 1996, total world shipbuilding is forecast to increase. Ever increasing intercontinental trade (90% of which moves by ocean transport), and the need to replace an aging world cargo fleet will increase demand early in the next century. Prices for new ships are expected to increase during the next 10 years because most European countries want to eliminate shipbuilding subsidies and other support policies.

While the US shipbuilding industry lags behind many nations in the world orderbook for new ships, it has shown some improvement. The US is now in ninth place (up from 23rd in 1996) with 1.8% of the world gross tonnage orderbook (see Figure 1). Japan and S. Korea dominate the market with 30.9% and 28.9%, respectively (MARAD, 1997a).

Figure 1: Commercial Shipbuilding Orderbook



US Shipbuilding Industry Trends

Despite some recent upturns, US commercial shipbuilding went into steady decline since construction differential subsidies expired in 1981. Continued government subsidies paid by competing nations further pushed the US industry into a less competitive posture. US commercial infrastructure deteriorated while the naval construction yards boomed during the military buildup of the 1980s. The post-cold war defense contraction has made the military construction industry ever more reliant on government support to remain viable as a component of the defense industrial base. In March 1998, Newport News Shipbuilding announced it was withdrawing from the commercial shipbuilding market because of significant losses associated with a double hull, petroleum product carrier (dubbed "Double Eagle") contract. Now it will only complete five of the originally planned nine Double Eagle vessels. This represents a significant setback to US entry into large commercial shipbuilding. Newport News Shipbuilding continues to build the Navy's aircraft carriers. Preliminary concept work is under way on the future carrier, CVX.

The number of naval ships under construction in US yards continues to decline. The Navy's FY 1998-2003 shipbuilding program projects an average of about six new ships per year. This represents more than a

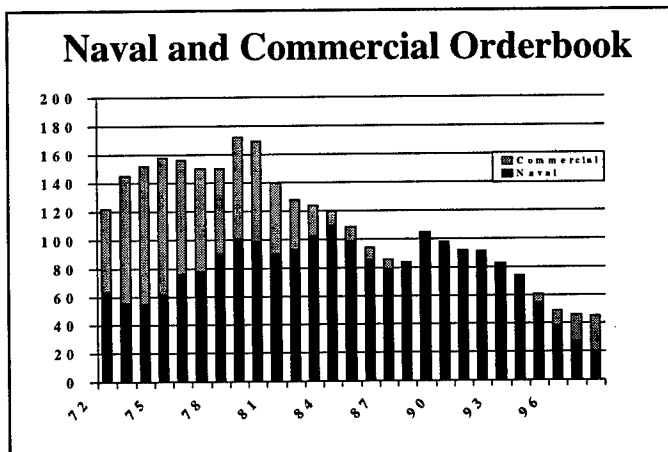
60% reduction in the quantity of ships procured, compared with naval ship output in the 1980s (MARAD, 1997b). The *Quadrennial Defense Review* (DoD, 1997) posits a requirement for a 300-plus ship fleet of 12 carrier battle groups, 12 amphibious ready groups, 116 surface combatants, and 50 attack submarines which translates into fewer new ships per year. This difference between current and projected creates the conditions for a significant modernization production lag in the out years beyond the current program. Notwithstanding funding availability, a key implication of this lag will be access to an adequate workforce to meet demand.

The Gulf Coast shipyards are experiencing a significant, albeit localized, labor shortage due to competition from the boom in offshore oil production. Nevertheless, the industry experienced a 44% overall decline in employment over the last 15 years (MARAD, 1997b).

US Industry Productivity

The majority of US construction is in military contracts and domestic Jones Act vessels. This act requires vessels in domestic trade to be US built. As of December 1997, the US shipbuilding orderbook for US private yards totaled 42 naval vessels and 12 commercial ships for a cumulative total of 54 (MARAD, 1997b). The US shipbuilding industry is doing minimal new construction in commercial ocean-going vessels. However, they are supporting the current US requirements for naval vessels. Figure 2 portrays the US orderbook history since 1972.

Figure 2: Naval and Commercial Orderbook



Recently, US shipyards concentrated on mitigating productivity problems in resource constrained areas of facility infrastructure and labor. In 1997, the industry invested more than \$244 million in upgrading and expanding facilities. Improvements for commercial yards included new pipe and fabrication shops, dry-dock extensions, and automated steel process buildings. In addition, US shipbuilders plan to spend \$256 million in 1998 on further facility upgrades and expansion projects (MARAD, 1998). With respect to the labor shortage, most US shipbuilders have contracts with local vocational schools and have established on-site facilities for additional training and apprenticeships. These local programs have wide variance in program content and the skill level of their graduates. They are insufficient to alleviate the spot labor shortages that currently exist in the US Gulf Coast shipyards.

European Industry Productivity

With some exceptions, European Union (EU) shipyards demonstrated greater productivity and process control than their US counterparts. Shipyard management and ship owners reflected a consensus on what makes an efficient and competitive operation. *Specifically:*

- Naval and commercial work should not be done in the same yard.
- Costing and accounting systems for naval work are very different from commercial construction, necessitating separate (and costly) systems.
- Ships differ widely in design and purpose. Specialization is required to achieve production economies of scale. Yards tend to become containership yards or passenger and ferry yards, etc., but maintain the capability to produce other types of vessels to react to shifting market demand.
- Transferring production from one type of ship to another is always difficult. When stepping down from high- to low-complexity, the workforce, trained at the higher technical level, will build excessive quality into the more basic ships, wasting labor-hours. When stepping up in complexity, retraining and rework may be expected, thereby raising costs.
- Outsourcing is essential. Successful European shipyards erect steel (30-40% of the final value of the ship) and contract everything else out. Even such things as scaffolding and rigging were often contracted. In two cases, complete sections of the ship were subcontracted to specialty contractors.

- Capital investment strategy:
 - Continual investment to improve computer-aided design/computer-aided manufacturing capabilities. Europeans often cite their in-house design capability as their greatest asset.
 - Investment in automation to minimize material flow. Moving large subassemblies in the building process is labor intensive. Hence, investment here offers significant return.
 - Investment to reduce construction labor hours in other areas.

Current Legislative Initiatives

US legislation affecting the industry has three objectives: to maintain the defense industrial base; to create a level international playing field with respect to subsidies; and to create commercial business opportunities for the US shipbuilding industry.

The National Shipbuilding and Shipyard Conversion Act of 1993 was intended to ensure the future availability of sufficient naval and cargo ship building capacity. This act expanded Title XI financing (i.e., federal loan guarantees) and instituted the Maritime Systems Technology (MARITECH) program. The expanded Title XI initiatives helped the US commercial shipbuilding industry by reducing the cost of capital for domestic and foreign shipowners. Further over the last 5 years, MARITECH has funded 66 projects valued at \$349 million, enhancing US shipyard efficiencies through facility and technology improvements.

In 1994, in response to complaints from US shipbuilders, the Clinton administration concluded an agreement for the elimination of worldwide shipbuilding subsidies with the Organization for Economic Cooperation and Development (OECD). The American Shipbuilding Association (ASA), representing the Big Six, opposes the OECD agreement. It will have significant impact because it will reduce Title XI financing guarantees from 87.5% to 80% coverage for a maximum repayment period of 12 years versus 25 years as currently written. The ASA holds that Title XI financing is the only incentive attracting foreign ship buyers to US shipyards. To date, all signatories (EU, Sweden, Japan and Korea) except the US have ratified the OECD agreement. The OECD agreement is aimed at leveling the international playing field with respect to elimination of subsidies.

The ASA is also concerned that the agreement threatens the provision of the Jones Act that requires vessels in domestic trade to be US built. In addition, ASA members resent that the OECD agreement

allowed European yards to reserve a last round of \$8 billion in subsidies for yard improvements while allowing no similar investment by the US government. Conversely, the smaller, more competitive US yards favor the agreement. After 3 years of debate, Congress still seems unlikely to approve the agreement and pass enabling legislation anytime soon.

EU shipbuilders are extremely disappointed the US has not ratified the OECD agreement. European shipyards feel US participation is important to ensure all signatories maintain the spirit and the intent of the OECD agreement. Nevertheless, because the countries of the EU agreed that they could no longer afford to continue to subsidize the industry, the EU recently decided unilaterally to proceed with its own program that is consistent with the intent of the OECD. The agreement will limit direct subsidies to 9% maximum and eliminate them entirely over the next 3 years. In addition, European efforts will be redirected toward investment grants for stimulation of research and development, modernization, and support for shipyard closures. European shipyards will continue to reduce costs and improve efficiencies through new construction methods. For the EU, US ratification of the agreement will have two primary impacts. First, US compliance will improve global competitiveness in the shipbuilding industry. Second, the persuasive force carried by US approval may be useful in buttressing Far East compliance with the agreement.

In 1997, the city of Philadelphia induced Kvaerner Corporation of Norway to renovate its former naval shipyard as a private operation, made possible by \$400 million in local, state, and federal funds. Kvaerner's vision is to build and operate the leading commercial shipyard in the US by 2002. The key elements will be state-of-the-art facilities, extensive training programs for the workforce, development of a competitive subcontracting business, and access to and implementation of Kvaerner's technological knowledge and shipbuilding expertise. Kvaerner plans to start production of the first ship in June 1999 and deliver by June 2001. This new shipyard may stimulate healthy competition in the US and lead to revitalization in the US commercial shipbuilding sector. It remains to be seen how reopening this yard will effect the shipbuilding overcapacity that currently exists in the US and the world.

CHALLENGES

The shipbuilding industry has yet to embark on the consolidation and merger path followed by most US defense contractors after the cold war. The Big Six shipbuilders are generally operating well below capacity due

to the significant slowdown in Navy construction orders. Combined with their lack of competitiveness in the commercial market, large US shipbuilders face potential collapse under their own inefficient weight unless they act to become leaner and more streamlined.

Productivity

One key challenge facing the US shipbuilding industry is comparatively low productivity. The shipbuilding industry has suffered from an array of problems that leaves it trailing its international competitors. The US takes twice the EU labor-hours and four times the Japanese labor-hours to produce a comparable ship. This productivity gap appears related to work preparation, gathering materials, and moving components vice time to weld or to assemble. In other words, it is a problem—not a management and facility problem. Pay is not the issue. Japan, the leading producer in the world, and Germany, the fourth largest producer, pay substantially higher wages than the US.

Japan has reinvented a traditionally American prescription for success in the search for improved productivity. After suffering from similar inefficient production processes that plague US shipbuilders today, Japan embarked on an aggressive campaign to convert labor-intensive shipyards into high-tech, mass-assembly workplaces (Glain). The Japanese shipyards realized it was the workplace and not the worker that was holding back its industry. According to an interview with a senior Navy source, despite a recent upturn, the US shipbuilding industry in recent years has seen relatively level or declining capital expenditures in response to its problems of poor productivity.

Low Profits

Another issue challenging the shipbuilding industry is the low profits that accompany the high risk. According to MARAD, shipbuilding firms typically average a 3-4% return on investment. Since potential investors normally expect greater returns for high-risk ventures, entry into the market or significant reinvestment is stymied.

Several factors complicate the pricing mechanisms in the worldwide shipbuilding industry. First, government subsidies mask the true cost to the builder. A significant advantage accrues to those companies (and countries) with more favorable government support. Second, current market conditions exacerbate the problem. As the near-term (through 2005) demand for commercial ships declines, over capacity in shipyards will exert further downward pressure on the price of ships. Some foreign

shipbuilders buoyed by the financial backing of their governments to save jobs and to protect industries, sell ships on the market at low prices. One industry expert stated that "the price of a ship has nothing to do with the actual cost to build that ship."

Foreign Subsidies

The US shipbuilding industry cannot compete against heavily subsidized foreign yards. Recognizing that foreign subsidies seriously disadvantage US shipbuilders, the US government began pursuing the elimination of subsidies worldwide in 1989. The effort resulted in the 1994 OECD shipbuilding agreement, mentioned earlier. At present, the US shipbuilding industry is widely fragmented on this issue and is challenged by the need to come to a consensus to settle the internal debate and send a signal to the world shipbuilding community.

Marketing Practices

Poor marketing practices haunt the US commercial shipbuilding industry. Due to dependence on reliable Navy requirements in the past, US shipyards allowed their marketing skills to decline. The US industry is weak in its basic understanding of the market overall and the segments that comprise the global market. US shipbuilders also have a bad reputation in the industry. They traditionally seek to resolve disputes in the courtroom, have been tarnished by their difficulties in dealing with the Navy, and often seek solutions to cost overruns through costly contract changes. Furthermore, the industry has been deficient in meeting other important customer needs, especially timely delivery. However, the quality of US products is high and is not an issue with potential customers. Also, US shipbuilders lack opportunities to develop long-term relationships with potential commercial customers, engage in too much bureaucracy from years of dealing with the Navy, and use poor buying practices for necessary materials (e.g. just-enough or just-in-time). Shipyard reliance on Navy contracts has tended to dull the competition in the industry. While profits are hard fought for in the commercial business, government contracts generally insure reasonable profits.

Skilled Labor Shortage

The shortage of skilled labor is another major issue facing the US shipbuilding industry. This condition exists in the commercial and naval

construction sectors. In 1996, Navy new construction employed 43,826 workers out of a total industry employment of 99,946. In 1997, the cohort declined 20% to 35,218 workers, with a 17% decline in total employment of 82,591 (NAVSHIPSO). The challenge for naval shipbuilding derives from the prospect of a production lag between the current production rate and the that would have been required to meet a 300-plus ship out year requirement. The Big Six must find ways to retain today's skilled labor pool in the yards to meet future requirements.

Looking outside ship construction for relief is not a panacea. Some key skill shortages, such as welding and shipfitting, compete with other industrial sectors where shortages already exist; thus increasing the difficulty in making up the shortfall from outside the industry. Going into nonshipbuilding work is easy for shipyard craftspeople. However, it is difficult to draft welders or pipefitters from other construction employers to bring them into the world of military specifications if they have no prior experience in that arena (NAVSHIPSO). Furthermore, recapturing skilled shipyard workers is not easy once they leave the yard for other employment.

OUTLOOK

The Short-Term Outlook

The US shipbuilding industry will see the status quo continue in the short-term. The Navy will remain the industry's number one customer. Constrained defense budgets will keep Navy construction at about six ships per year.

The industry does not forecast a large upturn in commercial construction in the Big Six yards. The recent example of Newport News Shipbuilding's withdrawal from the large, commercial tanker market may be an indicator of the future scrutiny and caution that the large yards will need to apply to future decisions before venturing into this highly competitive market.

The continued existence of some shipyards may hinge on how successful they are in adding to their commercial orderbooks. Unfortunately, all of the yards the study group visited agreed that they could not compete head-to-head with the heavily subsidized foreign competition. Most yards agreed that US shipbuilders must find a niche in which they can become internationally competitive. Avondale was exploring the possibility of building technically complex specialty ships, such as Liquid Natural Gas (LNG) carriers.

Most yards were content to build Jones Act vessels, refusing to take risk in the global market. However, the annual demand for large Jones Act ships is not enough to sustain the Big Six yards at current levels of employment. Some yards will increasingly turn to the conversion and repair business while others will downsize labor pools to match the low demand for large ships.

Fortunately, resurgence in offshore oil exploration is providing Gulf Coast shipbuilders all the work than they can handle. Orders for oil rigs and OSVs promise to keep these smaller yards in the black for the next few years. Overall, however, the prospects for Big Six commercial successes remain uncertain, and there is ample cause for pessimism, especially in light of Newport News Shipbuilding's recent retreat from its Double Eagle commercial tanker construction foray.

The Long-Term Outlook

World demand for commercial ship construction should increase after 2005 due to fleet age and replacement requirements. The long-term outlook for the US industry is bleaker. Within the next decade, it is likely that one or more of the Big Six will fall victim to the competitive forces of a much smaller shipbuilding market, unless there is direct government intervention or they are able to break into the international market. There are only eight tankers and two cruise ships on Colton Company's list (a well-known marine industry consultant) of pending commercial contracts (Colton Company, 1998). Ten ships per year would be required to sustain a fleet size of a 300-plus ship Navy. However, the necessary 50% increase from the current and near-term Navy building rate will probably not be realized due to mounting budgetary pressure for further defense cuts.

OPA 90 requires all tankers entering US ports by the year 2015 to have double hulls. MARAD reports about one-third (1,500) of the world's petroleum tanker fleet enters US ports; 40% of these tankers were built between 1972 and 1977. They will be 25 years old by the year 2000 and will require replacement with new double-hulled vessels in compliance with OPA 90. Jones Act tankers could possibly keep all of the Big Six yards alive for another 15 years.

In the future, there likely will be more contractor teaming in the construction of both military and commercial vessels. For instance, the following companies have teamed up for construction projects: DDG-51 Arleigh Burke (Ingalls/Bath), LPD 17 (Avondale/Bath), and SC-21 Future Surface Combatant LDD-4 (Ingalls/Bath/Lockheed Martin or Raytheon). This will facilitate the sharing of technological, managerial,

and marketing strengths necessary if US yards are going to compete on the international market.

As with other defense sectors such as aerospace, consolidation and mergers among the Big Six may loom in the future. However, the ultimate number of naval new-construction shipyards depends on the Navy's determination of how big a fleet it can afford, and how it will award contracts. Notwithstanding the legal requirements for sufficient competition, one possible variant of new management structures caused by consolidation is the ascendancy of the system integrator as prime contractor instead of the hull maker, like the new British LPH. This is a markedly different approach from today's convention of a prime contractor selecting an integrator in a competitive process. It speaks to the increasing importance of the role of the process of combining a ship's system suites vice the relatively straightforward task of building the hull.

Although the MARITECH program has done much to help US shipbuilders close the technology gap, the US is still several years behind most of the highly automated European and Asian yards. Unless the OECD agreement is ratified, foreign subsidies will provide a rate of capital investment that US yards cannot match.

To date, US shipbuilders cannot reach consensus on a position regarding the ratification of the OECD agreement (with special attention to the Jones Act exemptions and the extension of Title XI loan provisions). Without the OECD agreement, heavy subsidies in the Far East will perpetuate current market conditions despite the EU's desire to eliminate such government support.

Congressional approval of a substantive charter and build program for naval support ships would bode well for the shipbuilding industry and ensure adequate attention is paid to filling a critical component of our fleet requirement. Despite certain objections from the US Senate, charter-and-build is an attractive alternative if the Navy is to replace its rapidly aging logistics fleet with the new ADC (X) support ship.

The American shipbuilding industry today can meet the nation's security requirements. However, an assessment of the long-term outlook for the industry, in light of flat or declining defense budgets, must entail an examination of the policies by which the nation will approach preserving its major naval shipbuilding base.

Maintaining a Skilled Labor Force – Peacetime

Beyond the year 2003, the Navy would need to project a 10-plus ship per year production rate, in order to support a 300-plus ship fleet. However, there is an arguable improbability that the Navy will be able to afford this much new construction. However, one can also assume that political influences will agitate for keeping all of the Big Six yards open. Therefore, a major concern that must be addressed is whether or not there will be enough skilled workers, particularly welders and shipfitters, to meet this projected outyear production lag (or “bow wave”) of increasing Ship Construction and Conversion (SCN) construction.

The challenge for the Navy will be preventing this production lag from decimating the labor force in the interim, resulting in a lack of skilled workers available for the out year upturn. This is a particular concern for low density, very highly skilled nuclear system construction workers. US efforts at concurrent commercial shipbuilding in the Big Six yards can maintain the skill base. However, absent a significant resurgence in large commercial work, the Navy will be constrained to using its acquisition strategy to keep skilled labor in the yards. Specifically, spreading out production schedules, negotiating multiship, accelerated production contracts, and allowing naval shipbuilders to charge portions of their commercial overhead to existing naval contracts (under the provisions of legislation contained in the Shipbuilding Capability Agreements Program).

Anecdotal evidence suggests that only 10% of skilled welders who leave a shipyard are ever rehired, meaning 90% found other employment or are otherwise unwilling or unable to return to the shipyard (NAVSHIPSO). Another factor that will impact future surge capability is that skilled shipyard labor is not very mobile. Shipyard workers tend not to relocate because the industry lacks long-term stability. Workers are less inclined to move their families, particularly with the increasing numbers of working spouses, whose reemployment in a new area would be uncertain. Wage premiums, adding to production costs, could lure some of them back in the event of surge demand. Recent organized labor objections to temporary foreign worker permits successfully shut off this source of labor. Politically, it is unlikely that foreigners would become a viable source of labor to meet a surge demand. Finally, for reasons of maintaining technological superiority and proprietary security, it is likely that the US will always maintain an indigenous naval construction industry.

Maintaining a Skilled Labor Force – Surge and Mobilization

The issues regarding preserving a surge or mobilization potential rest on an understanding of our industrial mobilization policy today. The 1995 Joint Strategic Capabilities Plan (JSCP) shifted the focus of military-industrial mobilization planning. With the end of the cold war, the US military will no longer plan to fight and sustain a global war. The focus and even the terminology shifted from industrial *mobilization* planning to industrial *preparedness* planning (Chairman, Joint Chief of Staff, 3110.13, *Joint Strategic Capabilities Plan*, 1997). Although the change in terminology seems minor, the associated change in policy is far-reaching. Emergency production capability will no longer be created and maintained at government expense. The military will assume the role of a world class customer interacting in a competitive and global marketplace. Direct investment in the industrial base would be considered only for the following situations: commercial suppliers are unable to respond to a Regional Commander-in-Chief's requirements in a timely manner or in sufficient quantities; or an item or capability is military-unique and not compatible with commercial production operations (*Joint Strategic Capabilities Plan*, 1997, pp. B-1, 2).

The shape of the shipbuilding industry's future peacetime competitiveness and wartime surge capability will remain unsettled until Congress and DoD answer the previously posed, fundamental questions. What size navy is the nation willing to pay for? Should new construction contracts be let without regard to the impact on the Big Six?

The US commercial shipbuilding industry is highly competitive in the worldwide small ship and specialty craft market, recognized for quality, technical superiority, and on-time delivery. There is every reason to believe this trend will continue. If Congress and the Navy decide to award SCN contracts without regard to their impact on the Big Six yards, it is not a forgone conclusion that these yards will go out of business. The US commercial shipbuilding industry's future profitability will depend on improving productivity in a number of ways. It can move to reeducate management and to recruit new design and engineering talent into the industry. The industry must restructure around multiskilled production teams, improve production efficiency, and provide avenues for shipyard workers to earn more and improve shipyard working conditions. The shipbuilding industry must learn to become creative and aggressive marketers of their products all over the globe, going head-to-head with competitors to establish relationships with buyers and to gain their trust. Finally, it must reduce production costs deliver quality goods on time.

GOVERNMENT GOALS AND ROLE

The role of government in association with the shipbuilding industry is to ensure that current and projected national security requirements and economic objectives are met. National security requirements include ensuring that the industry can produce and repair US military and sealift ships and that capacity exists to increase production of these types of ships, and ensuring sufficient merchant shipping is available to support US military and economic interests. Achieving the US government's goals has become increasingly complicated since the end of the cold war due to Navy downsizing and the Big Six's unsuccessful reentry into the international large commercial ship market.

Government Role in Military Shipbuilding

The US government supports the shipbuilding industry primarily through protectionist legislation, such as the Jones Act, Passenger Services Act and the National Shipbuilding and Shipyard Conversion Act and congressional appropriations for Navy ship construction. Nevertheless, market forces should determine the composition of the shipbuilding infrastructure. US programs in which government and industry collaborate in commercially useful, military ship research and development would support the national military and economic strategy. These programs could be government-funded or funded through shared government-industry funding.

Government Role in Commercial Shipbuilding

US shipyards must eventually compete in the global market for commercial and military export shipbuilding contracts. However, legislation such as the Jones Act, which affords US shipyards protection from foreign shipyards, helps preserve the US shipbuilding base. Market-oriented policies preclude government funding as the sole solution to strengthening the domestic shipbuilding industry. Therefore, government and industry cooperation is the most economically viable answer to the problem. Moreover, unless the bow wave of Navy requirements materializes, the MSB shipbuilders may need to establish domestic or overseas teaming partners to survive. Teaming is a viable strategy to enhance US competitiveness in the global shipbuilding market. EU shipbuilders are taking advantage of this approach. The

Horizon area air defense frigate involving French, Italian, and British government cooperation is one such example.

The US government must maintain an active role in the US shipbuilding industry—but not by determining which yards remain open. The study group recommends the following areas for continued government involvement in the shipbuilding industry.

- Ratify the OECD agreement with proposed amendments.
- Overwhelmingly, US shipbuilders agree that foreign governments' subsidies to their shipbuilding industries inhibit US shipbuilders from competing in the commercial shipbuilding market. Approval of the OECD agreement would eliminate most direct subsidies and limit trade-distorting financing programs by the nations that signed the agreement. The danger of foreigners using the agreement to take Jones Act construction away from American yards is minimal. In that event, Navy and MARAD's industrial base concerns would spearhead the drive to withdraw from the agreement.
- If Congress cannot implement the OECD agreement this session, the administration should make clear its intention to abide by the "standstill agreement" which pledges no new subsidies between the drafting of the agreement and its entry into force. Notwithstanding the standstill provisions, the US should not give up the Kvaerner/ Philadelphia deal that will bring new managerial and technical tools into American industry.
- Continue existing low-cost and high-productivity programs such as Title XI financing and MARITECH, scaling them back only if required by entry into force of the agreement. These programs are key to improving processes and technology, enabling the industry to compete internationally.
- Modify current procurement philosophy to promote competition, consolidation, or teaming among the tier one shipbuilders for government shipbuilding contracts. However, maintain an industrial base floor of MSB shipyards to promote competition for Navy work.
- Continue acquisition reform to adopt commercial best business practices to make US yards more productive and competitive.
- Allow current protectionist legislation such as the Jones Act and the Passenger Services Act to remain in force. Removing these protections will eliminate recent US gains in the international commercial shipbuilding market.
- As necessary, review and modify legislation that would permit US shipyards greater latitude in participating in the Foreign

Military Sales market. This "niche" approach to shipbuilding offers the best hope of capitalizing on productivity improvements and changes in government acquisition methods.

- Enact legislation that permits charter and build financing for construction of combat logistics force ships.
- The federal government should continue to encourage the construction of modern, large commercial ships in US shipyards.

CONCLUSION

This paper assessed domestic, international, military, and commercial ship construction to answer a single overarching question: *Can the US shipbuilding industry meet the national requirements of the US?* The answer is an unqualified yes. Ancillary to that question is the issue of the impact of a viable commercial shipbuilding capability on the national security. While the construction of commercial ships in US yards is not essential to national security, without increased commercial shipbuilding orders additional contraction of the current shipbuilding base is likely. Contraction of the base to produce only naval ships would have little impact on the national economy. A more robust commercial ship orderbook would, however, preserve sufficient capability for increased naval ship construction in the future.

Congress and DoD must soon decide whether government intervention or market forces will determine the future make-up of the MSB. Reductions in defense spending will prohibit military ship construction alone from sustaining the industrial base without prohibitive SCN budget increases. If market forces drive the shape of naval shipbuilding, there will likely be consolidation and reduction to something fewer than the current Big Six.

Congress and DoD must establish a long-term Navy force sizing strategy that will provide an indication of annual ship construction for at least the next 35-50 years. If the strategy calls for a smaller fleet (i.e., approximately six new builds per year), then we should consider consolidating naval construction into fewer private yards and husbanding the shipyard craft skills.

Commercial business success in the remaining naval shipbuilders appears to be the best hope for large-scale retention of skilled workers. Multiyear production contracts have a beneficial effect on program stability; overhead offsets should be viewed as an interim measure to growing a profitable commercial capability in our Big Six yards.

If the nation and the Navy are to benefit from having tier-one shipyards capable of successfully producing commercial ships, then US

shipbuilders must become more competitive in order to reap a share of the growing global market. Besides improved production processes, world class marketing skills, and aggressive targeting of niche markets, success in commercial shipbuilding will require, above all, a cultural change to move in a dramatically different direction away from the public's funds.

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SPACE

ABSTRACT

The global space industry is burgeoning. For the first time, the commercial sector's share of the space market has surpassed that of government. This trend will continue, driven by soaring demand for commercial communications and by a host of emerging technologies such as remote sensing and geographical information systems. According to an Air Force Space Command Brief, "...just as oil drove the engine of yesterday's Industrial Society space will drive tomorrow's Information Society." This new era presents a plethora of opportunities and risks for the US space industry and for the Nation's security. A fine line must be tread, for example, between protecting critical US technologies and falling behind in a fiercely competitive international market, thereby jeopardizing future national capabilities. The space industry has the potential either to promote international cooperation and mutual benefits for all nations or to create global winners and losers. Sound policy choices must be made now to successfully leverage the commercialization of space and to build for the future.

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INTRODUCTION

The theme for this year's space industry study, Leveraging Space Commercialization, recognizes that the industry is entering an era of vast commercial growth. This year (1998) marks the world's first satellite-based personal communications system, Motorola's Iridium, which will enable communications anywhere on earth and allow developing nations to leapfrog earthbound infrastructure. For the first time, in 1997, the commercial space market outranked government's share of the space sector by 53 to 47% (KPMG Peat Marwick).

This study examines ways to leverage the commercialization of space to ensure continued US industrial competitiveness and unfettered access to space for national security purposes. It compares US space policy, government, and private sector investments and overall industry trends to those in the international space industry, notably in France and Russia. The study's methodology consisted of individual student research, visiting lecturers, and domestic and international travel, including visits to public and private sector entities. The study focuses on the industry's health, including productivity trends, capital investment, business expansion and consolidation, research and development (R&D) levels, production capacity, political and social factors, and government goals and roles.

"Space will be the ultimate high ground for terrestrial success" (Chief of Staff of Army). The development of commercial space technologies is vital to US national interests and will revolutionize virtually every industry sector. Every military combat operation now relies, directly or indirectly, on information collected from space. Multispectral remote sensing imagery with one-meter resolution will revolutionize agribusiness, environmental management, mining and oil exploration, civil planning, and city services. New applications of the Global Positioning System (GPS) will modernize air traffic management and create markets for tracking anything that moves, from automatic vehicle location systems to scientific measurements of continental drift. Demand for reduced payload weight will foster new advanced materials and innovative manufacturing techniques. Space R&D will develop the next generation of miniaturized electronics, integrated circuits, and microcomputer systems. As fossil fuel use increases, space technology will not only monitor global warming, weather patterns and CO₂ emissions but could bring about a constellation of large solar power generating satellites to provide clean continuous electric power to the entire globe.

THE SPACE INDUSTRY DEFINED

Historically, space activities were considered to be simply a subset of the aerospace industry. In fact, however, the space industry cuts across a broad array of economic sectors such as telecommunications, information technologies, electronics, aeronautics, life sciences and many other traditional sectors.

(1997 Outlook: State of the Space Industry, KPMG Peat Marwick)

In broad terms, the space industry is defined by those activities that depend on or relate to having a satellite or other space-borne asset in orbit or in space relaying data back to earth. These activities include the manufacturing, testing, delivery and launch of satellites/spacecraft; the operation or utilization of satellites and other spacecraft outside the practical effects of the Earth's atmosphere; the manufacturing and operation of earthbound facilities to link with, control, interpret, and disseminate information and data from space-borne assets, and the commercial application of other space industry technologies, products, and services.

Besides the above activities, the rapid commercialization of the space industry has spawned tremendous growth in support services. Space insurance—prelaunch, in-launch, in-orbit, and third-party liability—has grown from a \$100 million capacity in 1987 to \$1 billion today (Brown). Mergers and acquisitions, capital markets, financial and management consulting, and others benefit from space industry growth.

The space industry in the US is defined by two primary sectors: the government sector (civil and military) and the commercial sector. Both sectors are supported by a space infrastructure made up of four primary areas, around which this study is organized: Launch, On-orbit Operations, Satellite Systems, and Applications.

The commercial space sector, the primary focus of the study, is being driven by telecommunications applications: telephony, personal communications systems, cable television distribution and direct TV and radio. KPMG Peat Marwick estimates that telecommunications applications now account for 30% of total space industry revenues and are projected to rise from \$23 billion in 1996 to \$46 billion in 2000. Other emerging applications include remote sensing (weather, environmental monitoring, crop assessment) geographic information systems, and GPS (navigation and tracking aircraft, vehicles and ships).

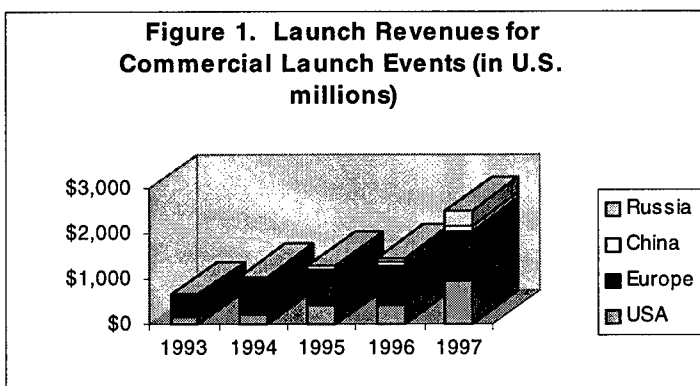
CURRENT CONDITION

The global space industry is healthy and increasingly competitive, with the commercial space sector continuing to grow at some 20% per year. According to KPMG Peat Marwick, "...the industry today can best be described by three words – growth, opportunity, and profit." Worldwide revenues reached \$79 billion in 1996, are currently estimated at \$85 billion and are projected at \$121 billion by the year 2000 (KPMG Peat Marwick). The US government is still the biggest single buyer, at \$28 billion per year for civilian and military uses. The industry employs some 800,000 people worldwide and is expected to create 70,000 new jobs per year (KPMG Peat Marwick). Commercial space is having a major impact on US jobs, new technologies, and economic growth that will continue into the 21st century.

Launch

The US maintains a significant space launch capability. Expendable launch vehicles include a host of proven platforms including Delta II, Titan II, Atlas II and Titan IV, and new smaller commercial entries such as Pegasus and Taurus. In addition to these expendables, the US continues to operate the Space Shuttle, the world's only operational Reusable Launch Vehicle (RLV).

Worldwide information and communication requirements have caused dramatic growth in commercial launch enterprises (see Figure 1).



While the US possesses a reliable and proven launch capability, it hardly dominates the commercial space launch sector. In 1996 the US launched just 36% of all commercial launches, the European Space

Agency (ESA) captured 43%, with the rest captured by Russia (12%) and China (9%) (Boeing Company).

High costs, enormous labor requirements, and extensive processing time hamper US competitiveness. An ESA Ariane rocket, for example, requires only 100 personnel and 10 days on the launch pad while a US Atlas averages 300 personnel and 55 days. Improvements are being made to shorten US launch times; for example, Delta II has reduced time on the launch pad from 40 to 28 days.

The US Space Shuttle fleet suffers similarly high operating costs and lengthy turnaround times; is almost 20 years old, and is in need of replacement. Historically, shuttle launches have averaged fewer than five per year, far less than the 12 per year envisioned. Costs are high at \$6,250 to \$12,500 per pound of payload to orbit. Turnaround times and cost to orbit of any proposed RLV replacement must be reduced.

In the past, access to space has required an extensive and expensive launch infrastructure, much of which has been developed and built by governments. Most launches have been conducted from sites in the US, Russia, Kazakhstan, French Guiana, Japan, and China. The sites in India and Israel have had nine launches between the two in the last decade.

Commercial activity has increased dramatically at all major launch facilities. Russian facilities, once exclusively government, now predominantly support commercial launches. US trends are similar—purely commercial launch and supporting facilities are being constructed in California, Alaska and Florida, where space authorities have been established to promote marketing and launch commercialization.

The industry is rapidly increasing launch capability, reducing costs, and developing new technologies to drive down time lines and manufacturing costs. Boeing's Sea Launch program (a multinational commercial effort consisting of a portable sea-based platform), Orbital Science's air-launched Pegasus, and the private funding of worldwide commercial spaceports signal a revolution in launch services. Many private concerns—largely US-based companies using private capital—are developing creative launch solutions ranging from modified conventional vertical launch to reusable systems for low earth orbit (LEO) satellites. Planned delivery costs are low at \$1,000 to \$5,000 per pound.

Satellite Systems

Commercial markets for space-based communications and imagery continue to grow while government budgets, at best, will remain flat. Planned satellite constellations such as Iridium, Orbcomm, Teledesic,

Globalstar, and Skybridge are launching dozens and even hundreds of identical communications satellites, changing the economies of scale and production techniques for spacecraft. Approximately 900 communication satellites will be launched in the next 9 years. Commercial communication spacecraft production is outpacing civil and military systems although government still leads in developing remote sensing, navigation, scientific, and experimental spacecraft.

Spacecraft Industry: Spacecraft production is transitioning from one-of-a-kind systems to larger scale production. In the past, satellites were custom-built at a cost of up to \$250 million each. "The customers who bought the first orbiting technology decades ago bear little resemblance to today's buyers. Satellites were exotic then, high-stakes jewels for intercontinental reach. Today they are implements bought for their power, reliability, and cost-effective performance" (Berry). Today's LEO satellites can cost as little as \$5 million to construct (Brown). Using technology proven on prior government systems and using breakthroughs in structural materials and microelectronics, commercial vendors now are able to apply mass production techniques to space systems. Emerging interface standards have allowed subsystems such as power, propulsion, avionics, and payloads to be more easily and independently integrated into spacecraft. These efficiencies have resulted in shorter development times, lower costs and commoditization of components and subsystems.

Government space systems—still characterized by unique requirements—are threat-based or mission-based, with specifications determined through peer review or other lengthy processes, adding time and cost to programs. However, in an effort to build "better, cheaper, faster" systems, the government has begun reducing rigid military specifications (MILSPECS) and special performance requirements and is exploring less stringent reliability testing. Reduced government expenditures, global competition, and rising customer expectations have forced the US spacecraft industry to undergo extensive consolidation, mergers and acquisitions, and form numerous international partnerships to remain competitive and to spread risk.

On-Orbit Operations

Security considerations have dominated military satellite operations, resulting in numerous fail-safe stove-piped operations centers, each handling a single satellite system. These numerous centers greatly increase personnel levels and increase the cost of satellite command and control. Some space operations have had good reason for redundancy and other high reliability requirements. For example, the

National Command Authority maintains a high level of expertise and redundancy in satellite operations to warn of missile attack against North America. Failure could hold dire consequences for the nation's security. However, stove-piped operations, redundancy, and high numbers of personnel should be the exception rather than the rule.

The commercial sector's profit motive drives operations differently. Commercial satellite operations are largely consolidated and characterized by low labor levels and great reliance on automation (operators are typically paged at home when a satellite departs from normal operations). To remain competitive and retain market share, commercial operations must reduce costs and explore technology and designs that minimize the need for human ground intervention.

Applications

Information. "The traditional basis for space-related business is being gently nudged aside by a new breed of entrepreneurs who think of space less as a scientific frontier than as a place to make money"(Shonfeld). Space-based systems provide access to information, a commodity as strategically vital as land, labor, or capital. "The explosive growth in communication satellites is extending high-speed data networking to every inch of the globe. Telecommunications systems are projected to expand from \$23 billion today to \$46 billion in the year 2000 (Erwin, 1998a). The demand for communication and information services (e.g., Internet, personal communication services, and wireless data systems) is fueling this subsector. Demand for Internet access alone will triple from 50 million users to 150 million by the year 2000. In late 1998 Iridium will make truly global telephone available for the first time, providing services to military and commercial customers.

Remote Sensing. Although the remote sensing sector is smaller than the communication satellite sector, it is growing rapidly, from the current 5% industry share, or \$4 billion, to a projected \$13 billion in 2000. Weather satellites are helping predict the course of hurricanes and tornadoes. Imagery is providing information for harvest planning, insect infestations, and soil erosion. Disaster relief organizations can get remote sensing information within hours of a disaster to help assess damage and determine the amount and type of resources needed for relief efforts. Insurance companies use remote sensing to quantify damage quickly for efficient claims processing. Environmental remote sensing gathers data about clouds, aerosols, and the Earth's surface interaction with the atmosphere. Industry growth has risen dramatically since the

1994 approval of US Policy on Remote Sensing, allowing commercial providers to provide high-resolution images of the Earth from space.

Navigation. Civilian applications of the space-based GPS, a constellation of 24 military navigation satellites, have grown exponentially. The civil, scientific, and commercial market for GPS applications, from air traffic control to iceberg tracking, now far exceeds its military counterpart and is expected to grow from roughly \$2 billion in 1996 to \$8 billion in 2000 (Nordwall).

CHALLENGES

While the cost of access to space is the primary impediment to commercial development, other major challenges remain for the government to leverage space commercialization effectively. The Justice Department investigation of Loral and Hughes illustrates the thorny issue of trying to promote US industry and free trade of space goods and services while preventing potentially harmful technology transfer. After a Chinese rocket carrying a \$200 million Loral satellite crashed in 1996, the two US firms allegedly advised the Chinese in order to satisfy insurers' concerns. Such advice — which could help China's military capability — did not receive prior State Department approval. This example illustrates the regulatory impediments US firms face regarding technology export. Thus, regulations and policies must be simplified and reduced, especially as international cooperation expands.

The space industry is encountering other challenges, including:

- Creating tax incentives to help new space industries (i.e. tax-exempt bonds to finance infrastructure such as spaceports);
- Preventing anticompetitive practices stemming from space industry consolidation;
- Ensuring adequate bandwidth and spectrum allocation for space-based communications, especially as numerous broadband systems start up after 2001;
- Removing impediments to licensing high-resolution commercial US remote sensing systems;
- Privatizing routine government space operations; ensuring wartime communications capability yet increasing government use of commercial assets;
- Turning GPS over from military to civilian control and adopting GPS as the global standard for position-location and navigation; and

- Resolving property rights, space debris issues and commercial space law issues.

Launch

Competition in commercial launch services will continue to spur improved reliability, responsiveness, and lower costs. The US space industry must therefore reduce costs and improve efficiency to compete with the ESA's Ariane and others. Russian, Ukrainian, and Chinese launch shares will grow, especially as bilateral agreements limiting commercial launches expire in 2000 and 2001.

The technological challenges of putting payload to orbit at less cost while confining launch vehicles to a single stage are formidable. Achieving airline-type operations requires upgrading thermal protection, rocket engines, and structural technologies. Although current multiple staging is reliable, improvements in reusable rocket engines and a single stage to orbit vehicle are needed to reduce cycle times and costs. Many proposed RLV systems will use vertical takeoff and horizontal landing, thus increasing launch infrastructure needs and turnaround time. Achieving horizontal takeoff and landing to reduce launch pad infrastructure requirements will be difficult.

Without cold war threats, maintaining government space budgets and programs presents a considerable challenge. The need for both expendable and RLV programs will undoubtedly face congressional and public scrutiny. However, because access to space covers a broad spectrum of needs (payload weight, orbit, replenishment, repair, retrieval, and manned decision-making capabilities) pursuing research on a single launch type would not be in the US national interest. Both launch technologies are promising. The US should not put all its eggs in the expendable launch basket, as other nations are now doing.

Satellite Systems

Competition. The consolidation of many aerospace contractors during this decade should lead to short-term savings for the government, but could mean less competition and monopolistic pricing in the future. The net benefits of consolidation must therefore be balanced with potentially negative competitive consequences.

The US space industry's global technology leadership is largely due to past government investment in military programs. However, continued governmental restrictions on technology transfers, put in place during the cold war, are now having deleterious protectionist effects resulting in

market distortions. In the new environment of global cooperation and competition, the US space industry will find it harder to obtain support and financing for foreign-based projects unless some technology transfer to host government or commercial entities takes place. Current US government policy on such transfers, as illustrated above, is contradictory, bureaucratic and ambiguous.

Production. Maintaining economical spacecraft production levels will be difficult as communication satellite constellations are populated and production drops to replenishment levels. As government and commercial entities trim infrastructure and personnel, sustaining mission-unique design capability will also be difficult. Government managers, facing severe fiscal constraints, will grapple with whether the existing technology development brain trust — consisting of contractors and captive laboratories nationwide — is sustainable.

Continued availability of key components and subsystems and viability of vendors and suppliers, especially for government programs, presents yet another challenge. Many suppliers now are opting not to compete for unprofitable, burdensome or restrictive government contracts. The availability of traditional high-reliability space-qualified parts will decrease as suppliers dwindle. The government will have to adopt more commercial practices and accept commercial hardware to stem the exodus of vital vendors and suppliers.

On-Orbit Operations

One of the government's main challenges will be to reduce satellite operations and maintenance costs. Force reductions have already changed military operations. For example, GPS control centers are now staffed with 70% enlisted personnel compared with 100% officers only a few years ago. Further personnel reductions and outsourcing will reduce training and other costs, but the impact of such reductions on surge capability during war is not yet clear. Consolidating operations centers to cut costs poses another set of issues for the government. The current effort to combine five Defense Support Program (DSP) control centers to one will reduce overall costs, but will add training costs and raise other security and operations tempo issues.

Advanced graphical software is being used to reduce education and training costs, increase operational efficiency, speed fault detection, and lengthen satellite life span. Reducing operational personnel and putting engineers on call will cut costs and improve commercial competitiveness but such steps will undoubtedly increase risks and could lengthen critical response time in case of satellite failure.

Applications

Information Systems. Roughly 15 to 17 new communications satellite systems, providing voice and data connectivity services, could go into operation in the next seven years (Evans). Most of these systems are US-based; however, all have international partners. The centralization of growth in the US market is causing concern in Europe, as evidenced by recent European resistance to spectrum allocation and orbital slots for US commercial entities. Other challenges are financing proposed communications satellite constellations totaling up to \$13 billion, expected market shake-outs and consolidations, and the technical and engineering challenges of developing and maintaining large state-of-the-art satellite constellations.

Remote Sensing: Many and varied challenges face the burgeoning remote sensing industry: demand for higher resolution; competition from foreign commercial sources (France, Russia, Canada, and India), and ensuring sophisticated computer software technology keeps pace with rapidly developing remote sensing technology while maintaining low costs. The remote sensing industry is also challenged by the development of new multispectral and hyperspectral imaging capabilities allowing for the extraction of more data from "before and after" images. Finally, governments and corporations involved in commercial remote sensing activities must comply with US restrictions involving export of this technology.

OUTLOOK

The outlook for the US space industry is bright indeed. The industry has the potential to create hundreds of thousands of high wage, highly skilled jobs and to become a major sector of the US economy in the next century. This is not to say, however, that US market dominance is assured.

As with other industries, consolidation, consortia, and shakeouts will be the bywords of the space industry for the next decade, as all global commercial space players jockey for position, hone competitiveness,

acquire technical competencies, and seek greater economies of scale. Such consolidation and cooperation will reduce the market and technical risks that dominate space development. Trends already seen in the consolidation of the US aerospace industry are now being seen in Europe, as firms such as Aerospatiale, Thompson, DASA, and Matra undergo continued mergers and acquisitions. International consortia such as International Launch Services (joining Lockheed Martin with Russia's Khrunichev and Energia) and Sea Launch (joining Boeing, Energia, Ukraine's NPO-Yuzhnoye and Norway's Kvaerner) are on the rise.

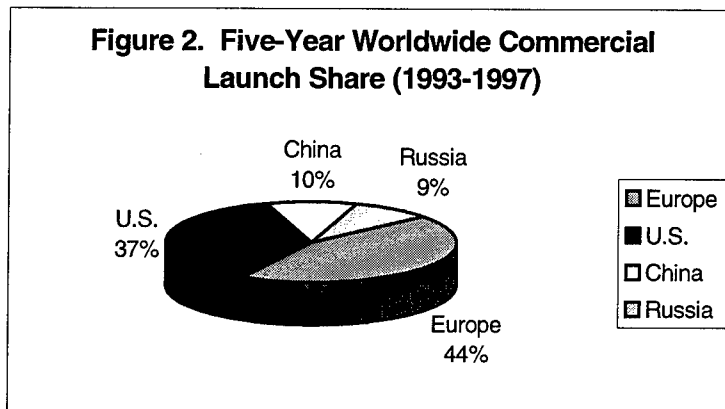
The US space industry will continue to face fierce competition from foreign commercial entities that have historically benefited from close alliances with and subsidies from government. The ESA's New Industrial Policy (NIP) is aimed at improving the competitiveness of European firms in international space markets through industry partnerships and government co-financing arrangements. The US commercial launch industry, in particular, will encounter intense competition from European, Chinese, and Russian launch service providers, many of whom enjoy government subsidies.

The primary competitors include Arianespace's new Ariane 5 rocket, which will carry heavier payloads in response to a worldwide trend towards larger satellites, and serve a range of orbits, from LEO to sun synchronous, elliptical, GEO and interplanetary space. Russia's Energia maintains world leadership in liquid rocket engine engineering. Its Proton rocket not only has heavy lift capability but also is one of the world's most dependable launch vehicles. China's Long March rocket, despite its current reliability problems, is still chosen by commercial entities for low price and quick launch. As its capabilities improve, China will not only become a major competitor but a huge market.

Launch

Demand for commercial space launch will lead to aggressive worldwide competition for market share. Approximately 70% of the 1700 satellites forecast to be launched in the next 10 years will be commercial communications satellites valued at \$58 billion (Erwin, 1998a). Figure 2 shows that Europe, Russia and China have already gained considerable market share. Increased competition will drive the market to provide more reliable and responsive launch services "better, cheaper, faster." Several US programs are being undertaken to do exactly that.

Figure 2. Five-Year Worldwide Commercial Launch Share (1993-1997)



The Evolved Expendable Launch Vehicle (EELV) program will replace the current US fleet of medium to heavy-lift expendable launch vehicles. The program's objective is to cut 25-50% of current launch costs over 20 years. Two different concepts will be explored through engineering and manufacturing development (EMD) contracts: one features the first new US-built liquid rocket engine in 25 years; the other will adapt the Russian RD-180 engine to a new Atlas version.

Several US programs will examine technologies to determine the feasibility of a shuttle replacement. Most prominent are NASA's X-34 and X-33 programs, in collaboration with the Air Force and industry. These are part of NASA's RLV Technology Program, whose goal is to develop technologies and operational concepts to reduce radically the cost of access to space. The program stresses simple, fully reusable designs with a goal of airline style operations. The Air Force is also examining various technological and operational aspects to develop a future military spaceplane. The Air Force will continue operational analyses and concept development to refine spaceplane requirements and approaches in the coming years, possibly leading to a suborbital demonstrator by 2005 to 2008.

Numerous commercial entities are pursuing creative solutions to space access, ranging from conventional vertical launch vehicles to reusable launch vehicles. Some of these new systems, like Pegasus (launched from aircraft) will not require extensive launch facilities.

Launch infrastructure will benefit from this growing demand. The accelerating trend toward commercialization will encourage new private spaceports to keep pace with increased launch activity. Competition will inevitably drive down the costs of space transportation and accessibility.

Satellite Systems

Space-based telecommunications will grow exponentially. Broadband multimedia satellite networks offering "Internet in the sky" such as the US Teledesic system and Alcatel's Skybridge will become operational by 2002. These and other systems will revolutionize personal and business telecommunications and introduce new fields such as telemedicine and distance learning in remote areas. These new space-based information systems may be expensive to maintain compared with existing ground-based infrastructure (fiber optic cables). As evidenced by the recent failure of the Galaxy IV telecommunications satellite — which silenced 90% of the 45 million US paging customers and thousands of cable television stations — the viability of the space market has yet to be proven. Alternatives such as fiber, or even high altitude balloon-based systems will be direct competitors for lucrative telecommunication markets.

Improved spacecraft production techniques and lower cost-per-pound of launch will likely enable more standardization and commercial off-the-shelf (COTS) purchase of major subsystems and components. Satellite bus designs and performance parameters will become more standardized and mission-unique space hardware and engineering will diminish. Pioneering science and engineering will likely become more esoteric and concentrated in fewer surviving centers of excellence.

On-Orbit Operations

Lower costs, efficiencies, service, and performance will drive both government and commercial sector operations. Cost will dominate both sectors: businesses will have to lower costs to compete and government downsizing and budget pressures will force it to seek lower costs.

Automation and exploding telecommunications are the best tools on the horizon to allow industry to achieve better efficiencies, service, and performance. The government will increasingly rely on COTS hardware and software. Standardization will permit consolidation of redundant operational control centers and telecommunications connectivity will allow remote access by staff. New capabilities will allow satellites to respond directly to user demands without need for operators. Standardized satellite architecture will lead to commonality in operations.

Applications

The information systems and remote sensing sectors are primarily driving the growing commercial space market. Navigation (GPS) applications are experiencing tremendous growth. When combined with new sensor technology and better precision location, virtually limitless new GPS applications will be developed ranging from deep-sea salvage to search and rescue operations. The development of other emerging markets, such as space tourism, solar power from space or mining of the moon or planets will depend on major technological advances or huge capital investments. Military missions such as force application and space control could be conducted in the near- to mid-future if budgetary and political obstacles can be overcome.

Information Systems. The market outlook for communications satellites and services is extremely promising. Soon worldwide coverage allowing voice and data connectivity will be available to not only business travelers, but also more importantly to populations in developing countries. These capabilities will allow many developing countries to leapfrog current ground-based technologies, thereby avoiding prohibitively expensive infrastructure investments required for a communication system backbone.

Remote Sensing. This sector has strong growth potential, especially as the technology accelerates and as more commercial applications for its use are discovered. The need for enhanced spatial and spectral resolution and hyperspectral remote sensing requirements will continue to expand. Recent US policy changes have allowed the remote sensing market to open up to commercial enterprises.

GOVERNMENT GOALS AND ROLE

"...in space, our national security, foreign policy, and economic security are inexorably linked...We will either rise together based on space policies that treat our commercial success in this new information area as a tool that strengthens us, or fall together based on policies that inhibit our commercial technology lead...From a government policy perspective, we may need to rethink what it means to say something is "ours" vs. "theirs." What is at stake is nothing less than global US leadership of information technologies in the 21st century" (Calhoun-Sengor).

The above excerpt from recent congressional testimony succinctly highlights the increasingly international nature of space development and emphasizes the shifting role government must play to support and leverage the commercialization of space successfully. This study has identified three primary goals for the US government to pursue.

More emphasis on basic research and development. Government-sponsored R&D is essential to provide the necessary base to support the industry's technological and economic development. Industry does not have the resources or financial incentives to pursue the costly basic R&D needed to push technology and make the revolutionary leaps forward to improve productivity, bring down costs, and enhance US competitiveness.

Increased cooperation in international space activities. US industry participation in international consortia allows the spreading of risk and increased access to capital. It opens markets to US space goods and services and allows industry to focus on developing areas of competitive advantage rather than squandering resources to develop unnecessary in-house capabilities. In all but the most exceptional cases, government should strongly encourage and offer incentives for international cooperation. In today's interdependent global marketplace the economic benefits accruing to American industry will serve to enhance US national security. The recent House resolution urging the president not to enter into new agreements with China involving space technology could have a severe negative impact on American producers (Hughes alone stands to lose \$600 million in pending satellite sales) and could hamper US space industry competitiveness in the long term.

Less government spending on infrastructure and routine operations. Government budgets should shift from developing systems and conducting operations to advancing research and development of new technologies. For example, NASA must continue to get out of the business of operating shuttle launches and the military must examine its role in space launch as well. Government satellite operations centers should be commercialized for all but the most sensitive systems.

Launch

The exponential growth of commercialization of space represents a win-win situation for the commercial, civil and national security space sectors. Advances in launch vehicle technologies, efficiencies gained through economies of scale, and improved launch processes will result in "better, cheaper, faster" launch services for all users. NASA should get back into expanding basic research and limit its role to providing

support to the space launch industry similar to what the FAA provides to both commercial and military aviation. This role need not be primarily regulatory in nature, but one in which space transportation technology is advanced by furthering R&D activities.

Government should continue to advance launch vehicle technology by supporting the following.

- Enact legislation and put policies in place that will make it easier or cost effective for industry to pursue EELV and RLV technologies and operations. At a minimum, the Commercial Space Act of 1997, now in the Senate for consideration, should be passed. One section, allowing commercial launch providers to obtain licenses for reentry vehicles, is critical to make commercial RLV operations a reality.
- Enact economic incentives for industry engaged in EELV and RLV R&D and eventually operations. This would not be unlike incentives such as land grants given to the rail industry in the 19th century, expanding America's early frontiers and easing the economic burden of building a supporting rail infrastructure.
- As the government transitions from an operator of launch systems to a customer, it should once again focus on augmenting technology and advances in launch systems. Although budgets are limited, research, development, and testing focus should already be shifting from the X-33 and X-34 type RLV technologies to the follow-on systems and technologies for their replacements.

Satellite Systems

The technology driving commercial space leadership has primarily come from government-funded research. As for other sectors, government must continue to invest in the long lead, high risk, high payoff technologies—or provide appropriate tax incentives to industry to make such investments—that could lead to revolutionary change. A successful example of that research is the Quantum mechanical transistor developed at Sandia Laboratories. This research promises radical improvements in speed of operations (it is 10 times faster) and greatly enhanced packaging resulting in far smaller space-borne computer systems, reduced power consumption and lighter payloads.

The government must also continue examining commercial practices and judiciously eliminating military standards and specifications wherever practicable. The use of commercial systems and production methods should be sought to gain needed economies of scale.

On-Orbit Operations

Today's fiscal realities, the high operating costs of government facilities, and the maturation of the commercial space industry afford government an opportunity to redesign how it does business. New, cost-effective partnerships with industry would free up governmental funds for R&D instead of operations. Exiting the business of conducting routine command and control of space operations enables precious dollars to be shifted from today's operations to tomorrow's technologies.

One critical area needing further research, affecting both commercial and government operations, is in space debris identification and tracking to avoid on-orbit collisions. Significant improvements in tracking and identification are needed to avoid serious threat to space-based assets and operations, especially as communications satellites proliferate and as the International Space Station becomes operational. Although the government currently only tracks approximately 8,000 objects, it is estimated that there are some 150,000 other objects that, if striking a spacecraft, could cause operational failure (Tebo). Besides R&D, because space debris transcends national interests, the government must also enlist international cooperation to deal with this problem effectively.

Applications

"The United States space program is critical to achieving United States national security, scientific, technical, commercial, and foreign policy goals" (National Space Policy, 1996).

Policies, legislation and tax incentives should be put into place that encourage new applications from space assets. The capabilities and applications of space-based assets are poised to vault the world into the new Information Age through telecommunications, remote sensing, and navigation systems. Not only will commercial industry thrive as the number of uses for space assets increases, but government as well stands to benefit economically, sociologically, and politically. The long-term benefits of space-based applications and international cooperation will far outweigh any perceived short-term risks. Government should therefore consider the following.

- Explore incentives to encourage further exploitation of space-based telecommunications. This would include a serious examination into the elimination of redundant systems (especially military telecommunication systems) that commercial entities could

handle better. To accelerate the synergy between communication systems, the US government should consider supporting a universal standard for all types of wireless data. This action would also assist the burgeoning remote sensing industry.

- While recent policy decisions have assisted the remote sensing sector to enjoy fruition in the commercial market, more enabling legislation is necessary. Section 201 of the pending Commercial Space Act of 1997 would streamline procedures for commercial vendors to obtain a license to own and operate such systems. It would also create a presumption of approval for applications that comply with title requirements and would prohibit the federal government from duplicating US commercial provider activities unless significant savings could be realized. This legislation must be enacted.

Cross Sector Issues

International and domestic laws, regulations, agreements, and policy must continue to evolve to ensure US national security and commercial competitiveness in the future. Two areas that must be addressed include technology transfer and the commercial use of government facilities.

Technology transfer policies must be carefully examined to ensure they are in the best interests of the US. While America must contribute to the global effort to restrict weapons proliferation, US policy must not unnecessarily penalize US corporations. An approach proposed by the now Under Secretary of Defense for Acquisition and Technology, Dr. Jacques Gansler, is appropriate to meet both needs: "...export control of critical defense technologies has traditionally been under government management. In the future, the list of items that are controlled can be greatly reduced because in most cases economic competitiveness is more of a concern than national security. What needs to be done is to develop a very limited list of items that are critical for both commercial and military reasons (Evans)."

Expanded commercial use of government excess capacity and facilities would also support broader national security interests. While international debate rages on such forms of government "subsidies," pressures to increase fees charged to commercial entities for launches at government facilities should be resisted. The current policy of only charging commercial entities the direct costs of the launch facility should continue to promote US commercial competitiveness in the global market. However, the present system of sending these collected revenues to the US Treasury —where they become fungible and are applied to a

multitude of programs, not tagged specifically for upgrading our aging space launch infrastructure —should be changed.

CONCLUSIONS

The national and international space industry is healthy, with revenues growing rapidly at 20% per year. Launch, satellite systems and applications are driving (and driven by) an exploding information revolution, thrusting the world into a new era. Commercial uses of space are skyrocketing as new applications are found daily for navigation, telecommunications, and remote sensing; ranging from GPS transmitters, to tracking whales, to listing real estate using images from space. International competition is keen, especially in launch, applications, and satellite systems; yet, joint business ventures and international consortia are now the norm for space commercialization. While private sector investment is increasing dramatically, government spending levels (US and foreign) are static or decreasing.

The major challenges facing the US space industry are decreases in government spending, ensuring access to space, and overly restrictive technology transfer policies. As stated earlier, the government should pursue three goals the government to mitigate the impact of these challenges and establish enabling conditions in the future.

- Eliminate unneeded infrastructure and cease routine operations or activities with no long term strategic gain
- Use savings realized from above to increase R&D funding
- Foster and encourage international cooperation and joint ventures, both government and commercial

In an era of ever declining budgets, the above steps, especially investments in basic research, will ensure future improvements in critical space technologies and capabilities. Partnerships between industries and governments, both domestic and international, are proving successful and beneficial to all parties.

Cooperative programs with Russia may be an efficient way for the US to obtain inexpensive, but quality R&D. This would boost Russia's economy, maintain their space expertise, and contribute to a more stable long-term environment. Russia's space program now embodies the challenges of transitioning from a centralized command economy to a free-market society competing in the global economy. Some parastatal space institutions (Energia, Krunichev) appear to be doing well while others that have not adapted to a bottom line orientation are faring less well. With an aging infrastructure in serious need of upgrading and a

paucity of government revenues, Russia's space industry is relying on its proven robust hardware, its pure science and advanced theoretical brainpower, and its skills in applications of engineering disciplines. Russia's launch industry is formidable and well recognized; several international consortia are based in some part on Russian or former Soviet launch capabilities. However, without additional investments, Russia's premier space capabilities could seriously erode.

Europe's space capabilities will continue to put pressure on the US space industry, from its current and future remote sensing platforms to their Ariane 4 and 5 launch systems. Europe's equatorial launch facility in French Guiana (providing a 20% advantage in payload capacity to geostationary orbit) has generated new competitive concepts such as the US led international consortium Sea Launch. Closer cooperation between France's nascent remote sensing industry and the US intelligence community (defense and industry) is now being contemplated which could contribute to a maturing relationship with one of the US' long-term allies.

The US space industry can support current and future national security requirements of the US, despite some near-term concerns such as constrained launch capacity and responsiveness. US commercial participation in international consortia, joint ventures and cooperative development programs will continue to be in the best interests of all nations involved. If carefully structured, such cooperation will provide long-term economic, strategic and political benefits that outweigh short-term US military security concerns. While military risks must not be minimized, US policymakers must be careful not to constrain industry overly, especially in an increasingly interdependent global environment.

The commercial space industry holds enormous potential to improve and enhance our national interests and our quality of life. Well-considered and crafted policy decisions today will enable the industry to reach its full potential and in so doing, ensure national and global long-term security.

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STRATEGIC MATERIALS

ABSTRACT

A fundamental shift in thinking has occurred in the US over the past 50 years concerning strategic and advanced materials. Historically, the focus has centered on national defense, but with the increased globalization of national economies, a broader concept of strategic and advanced materials has emerged. The new perspective asserts that national security planning encompasses the broad welfare of a society, which includes economic and political as well as defense considerations. This broad perspective on national security is evident in many countries. The mechanism driving the strategic materials industry in this regard is the global market economy. Economic growth and prosperity has emerged as a primary goal in our national security strategy. Strategic materials both enhance the growth of our economy and promote national security. Therefore, it is vital to US national security that it maintains a commitment to further and continue development of these strategic materials industries.

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PLACES VISITED

Domestic

Alcan Aluminum Limited, Montreal, Quebec, Canada
Alcan Research Laboratory, Kingston, Ontario, Canada
Bethlehem Steel Works, Baltimore, Maryland
Canadian Institute of Mining and Metallurgy, Montreal, Quebec, Canada
Hydro-Quebec Research Institute, Montreal, Quebec, Canada
Industry Canada, Boucherville, Quebec, Canada
International Civil Aviation Organization, Montreal, Quebec, Canada
International Labor Organization, Washington, DC
National Research Council Industrial Materials Institute, Canada
Naval Research Laboratory, Washington, DC
Newport News Shipbuilding Company, Newport News, VA
Norfolk Naval Base, Norfolk, VA
Queens University, Kingston, Ontario, Canada
World Bank, Washington, DC
Zoltek, Environmental Technical Services, Technology Syndicate, Inc,
and LeMay Center for Composites Technology, St. Louis, MO

International

Agricultural Institute, Wieselburg, Austria
Austrian National Defense Academy, Vienna, Austria
International Atomic Energy Agency, Vienna, Austria
Ministry of Science and Research, Vienna, Austria
United Nations Industrial Development Organization (UNIDO), Austria
University Research Center, Tulln, Austria
US Embassy, Vienna, Austria
Voest Alpine Steel and Voest Alpine Technologies, Linz, Austria
Budapest Commodities Exchange, Budapest, Hungary
Danube River Commission, Budapest, Hungary
Hungarian Defense Force, Budapest, Hungary
Hungarian Environmental Protection Agency, Budapest, Hungary
Hungarian Iron and Steel Association, Budapest, Hungary
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INTRODUCTION

Strategic materials and minerals are an integral part of everyday life. They are at the very core of US industry. But every nation is not equally endowed with the materials needed to promote the welfare of its citizenry or the continued growth of its economy. Some regions possess great mineral wealth but lack the requisite technological know-how, means, or economic policies to adequately exploit the materials. Other countries lack such minerals but have managed to thrive nevertheless.

The US is in the exceptionally favorable position of combining a very deep and diverse resource base with the advanced technology and market-based incentives required to exploit its resources to satisfy both its civilian economic needs and its defense industries. When the US had concerns about sufficiency of certain minerals and materials, it established national defense stockpiles to assure these minerals and materials would be available when required. This report will highlight the changing conditions of the strategic materials industry in the US and selected other countries.

THE STRATEGIC MATERIALS INDUSTRY DEFINED

The term "strategic materials" does not refer to any specific industry. Instead, "strategic materials" transcends many different industries from mining, to those converting raw minerals into usable materials, to those using the materials in the manufacture of intermediate and end products for civilian and military use.

In order to study this "industry," it was necessary to further categorize strategic materials along two lines: traditional materials that have been used for many years and advanced materials, many of which have recently emerged or are still being developed. This study focused its effort on two traditional strategic materials (aluminum and steel) and two types of advanced materials (ceramics and advanced composites).

The members of the strategic materials industry fall into two basic classes. First, there are the large, publicly traded corporations involved in the production, manufacture, and use of traditional materials. Second, there are the many smaller firms or government-sponsored organizations involved in the research, development, and promotion of advanced materials. The market for special advanced materials continues to be concentrated in special fields where, for example, low strength-to-weight ratios are of primary concern and cost is a secondary issue (e.g. aerospace). The market for traditional materials continues to be

concentrated in areas where cost is of primary concern (e.g. construction).

Steel. Current steel making is accomplished by two basic methods. The first method, integrated steel making, is the process of making steel "from scratch," directly transforming iron ore into steel through two steps, melting the ore in a blast furnace and then adding alloys to the molten liquid to form hardened steel. The second method takes scrap steel and iron, melts this scrap down in a furnace heated by electric arc elements, and then again adds alloying agents. This recycling of iron and steel products is the electric arc furnace or mini-mill method. The industry overall is extremely energy-, capital-, and labor-intensive. Steel types and quality are defined by alloying agent purity and precision in casting and milling.

Aluminum. Aluminum is made through two basic methods. The first, the primary process, converts alumina (from bauxite ore) into aluminum through the electrolytic Hall-Heroult Process (HHP). The second, known as the secondary process, converts scrap aluminum into useable metal. This secondary method accounts for one-third of US aluminum production and is used almost solely in the container industry. Primary aluminum production is extremely energy- and capital-intensive. The secondary process requires only 5-8% of the energy required in the primary process. The US is the world's largest producer of aluminum.

Advanced Ceramics. Advanced ceramics are highly refined descendents of the ceramics we know in daily life as the material of dinner plates and coffee cups. Advanced ceramics have a long history in military systems, beginning in the late 1940s. Some of their good properties—hardness, compression strength, formability, imperviousness to high temperature, and chemical inertness—made them early candidate materials for improving the efficiency—both power to weight and fuel usage—of rocket, gas turbine, and piston engines. Hotter-running engines are more powerful, and even early ceramics showed potential to retain strength at far higher temperatures than metal alloys. From early days, advanced ceramics were also used for protective armor. Their controllable electrical and optical characteristics led to electronic "chip" packages and optical fibers.

Composites. Composites are man-made materials in which high-strength, high-stiffness fibers of one material are embedded in a supporting matrix of another material. The major classes of composite matrices are polymer, ceramic, metal, carbon/carbon, and hybrid (*National Advanced Composites Strategic Plan*). The principal advantages of composite materials are that they are lightweight and its high strength, flexible design and shaping characteristics, and corrosion

resistance. The most common uses of composites are for recreation and sports equipment and in the aerospace industry. Currently, the US has only a few qualified producers of the fabrics (woven fibers) used in the composite preforms. Existing producers have limited capacity, which contributes to very long lead times – greater than 6 months – even on large high priority programs (*National Advanced Composites Strategic Plan*).

CURRENT CONDITION

The US continues to be one of the world's largest users of traditional strategic materials. Its reliance on foreign sources for the basic minerals required to make these materials continues to grow. The US was once thought to hold the dominant share of worldwide production capacity for traditional materials like steel, but today there are major steel producers found on every continent.

With advanced materials, several countries surpass the US in production. For example, half of the world's carbon fiber manufacturers are located outside of the US, and the United Kingdom is the primary source of the acrylic fibers used in producing carbon fiber composites in the US.

Defense needs, particularly for aerospace applications, were the main drivers for greater use of advanced strategic materials during the 1970s and 1980s. However, with the end of the cold war, and the steep decline in defense spending, fewer dollars are available for research and development (R&D) of strategic materials. While commercial needs and applications have continued to foster development and growth of some strategic materials, high capital costs, the need for positive returns on investment, and the relatively modest cost of traditional materials have slowed the progression of advanced strategic materials in the marketplace. Unless the costs of advanced materials can be substantially reduced, their use in markets dominated by traditional materials (e.g. transportation and infrastructure) will be greatly limited.

Steel. After enduring the traumatic downsizing and restructuring of the 1980s, the American steel industry in 1998 is leaner and more competitive. Overall, US consumption of steel was about 140 million tons in 1997. Domestic integrated steel making is operating at over 90% capacity, but it should be noted that integrated steel *capacity has essentially not changed since 1985*. Electric arc furnace (mini-mill) steel production continues to gain in overall domestic market share, garnering 43% of the total US steel production in 1997. Foreign steel accounts for about one fifth to one quarter of all steel sold in America, a fraction that

has held relatively constant for over a decade. Steel has proven to be quite recyclable, with 57% of all steel produced in the US in 1997 having come from scrap iron and steel. Due to the worldwide abundance of steel, cost margins are very narrow.

The steel industry, with the immense amount used annually worldwide (approximately 700 million tons), is not known to be particularly innovative.

Aluminum. The US aluminum industry has been growing at about 3-5% annually, employs over 130,000 people, and contributes more than \$30 billion annually to US Gross Domestic Product. The industry is heavily dependent on imported bauxite. The majority of new plants are for secondary processing of recycled materials. High energy and labor costs generally render construction of primary processing plants unprofitable. The US possesses three of the world's top six aluminum producers. While imports have increased dramatically in the past 25 years, the US continues to export (about half the quantity it imports) and maintains some excess capacity. Stagnant technology is an item of concern. Aluminum producers have relied on the HHP since 1886. They have achieved several refinements enhancing efficiency and techniques, but the electrolytic process pioneered by Charles Hall's Pittsburgh Reduction Company over 100 years ago remains the foundation of today's industry. As a bottom line position, the aluminum industry is economically healthy, about the right size, but technologically stagnant.

Advanced Ceramics. The \$13 billion ceramics industry is global. The largest companies in the industry are in Japan, France, and the US. Japan's Ministry of International Trade and Industry targeted advanced ceramics with subsidies in the early 1980s and set ambitious R&D goals. Though many of these remain unrealized—a commercially viable all-ceramic engine, for instance—Japanese companies gained important manufacturing know-how through this program. Kyosera, a Japanese company, dominates the advanced ceramics electronic package sector, and Japan is the only country to employ complex advanced ceramic parts (turbocharger rotors) in mass-produced automobiles. The US dominates ceramics for chemical processes because ceramic-based catalytic converters proved the most economical way to meet government-imposed Combined Automobile Fuel Efficiency (CAFE) standards. Moreover, the US industry is accelerating again after years of modest growth because advanced ceramics technology is finally producing clear-cut commercial successes.

R&D has overcome many engineering problems. Despite this progress, ceramics remain expensive to manufacture. Though most of the base materials are common, some have high market costs. Achieving

high strength involves complex chemical purification processes with hazardous solvents. Baking ("sintering") of ceramics is slow—done in batches at high temperatures, up to 3000°F, in a controlled gaseous atmosphere, often in intricate molds under heavy compression. This is tricky work with a large energy bill. Final machining is also difficult because ceramics are so hard. Special diamond and ultrasonic cutting tools do the job, but at a high price. Economically practical technologies for recycling ceramics are not yet available, closing a door to savings. Continuous reinforcements create a whole new set of high-cost manufacturing problems, not yet well understood.

Given this background, advanced ceramics have their widest applications in small but vital niches within complex systems, rather than as major structural materials like steel or aluminum. There are two broad categories of uses. First, engineers can choose advanced ceramics merely because no other material will do as well (e.g., infrared and radar-transparent sensors.) Second, ceramic parts serve as one-for-one replacements for parts made of metal or another material (e.g., valve trains for diesel piston engines.)

Composites. At present, there is limited domestic availability of certain materials needed to fabricate large quantities of composite components. The basic raw materials used in advanced composites generally consist of glass, metal or carbon fibers, and resin. Glass fibers are widely available in the US, but carbon and metal fibers of the quality required are more difficult to obtain. For example, the US is currently dependent on Japan for carbon fiber (Fink). Unless the US develops alternate sources for carbon fibers — perhaps based in the US — or stockpiles sufficient quantities to meet contingencies, this dependency could have a negative effect on production and sustainment activities especially during times of high demand generated by defense buildups or future conflicts.

CHALLENGES

Steel. Since steel is now essentially a commodity, foreign competition will continue to be the dominant challenge for the US steel industry. To put it in perspective, in 1960, 39 countries made steel. In 1995, 92 countries were producing steel. The challenge will be sharpened in the coming years by an anticipated glut of Asian and Russian steel on worldwide markets. This challenge has to be met by continued improvements in productivity and cost efficiency in order for the US steel industry to maintain its share of the US domestic market. Competition with other countries in foreign markets appears unrealistic.

Aluminum. The aluminum industry strategy to increase market share centers on replacing steel products. Its price (2-4 times that of steel) is an obstacle to attaining that goal. Challenges include reducing the cost of the huge amount of energy used in its production, reducing greenhouse gas emissions resulting from production, rising to challenge new advanced materials, and developing a cheaper, more efficient primary production process.

Advanced Ceramics. The greatest challenge to exploiting advanced ceramics is to overcome industry's natural tendency to stick with familiar, traditional materials, in part due to prejudices inspired by old performance deficiencies that no longer exist. Wide industry employment of advanced ceramics is advantageous to DoD because it creates a favorable environment for dual use acquisition strategies. The following steps are needed: educate the design community on the growing capability and long-term cost advantages of ceramics; advertise the swelling list of commercial successes; codify design procedures and testing standards so that manufacturers and engineers can speak a common technical language regarding advanced ceramics; and foster R&D that reduces production costs and further improves performance in ways most relevant to commercial industry practices. As use of advanced ceramics materials becomes more widespread in regular industry practices, costs will continue to fall and applications will be easier to introduce in more defense-related products.

Composites. The expanded use of composites depends on the resolution of several issues. First, manufacturing costs must be reduced. Many manufacturing techniques used with composites are labor-intensive, require special tooling, and generally result in higher costs and slower rates of production than those experienced with traditional materials. Additionally, while conventional material (aluminum) can be had for around \$2 per pound, composites average \$5 to \$10 per pound. Second, standards and guidelines that can be used as references will have to be introduced and accepted as tools and guidelines by the engineering and logistics communities. Third, environmental issues have to be resolved. Most resins used in composite systems are hazardous. Composite fabrication and assembly usually calls for a new plant, with a controlled environment, sealed doors and specialized charcoal-filter scrubber systems, all built to conform with a phalanx of local, state, and federal regulations (Sweetman). Finally, reparability concerns must be addressed such as the lack of timely and effective procedures for detecting and repairing damaged composite structures. Dr. Bruce Fink, a composites expert at the Army Research Laboratory, says: "detecting damage in composites is much more difficult than you might

imagine...ultrasonic imaging to find defects isn't available in the field and integrated armor cannot be interrogated using C-Scan. Other techniques are required" (Fink).

Deep Seabed Mining. Growing demand for the world's natural resources places the US in a position of facing increased competition for many nonfuel minerals. There is no doubt of the immense quantities of valuable mineral ores available on the seabed floor, particularly cobalt, copper, nickel, and manganese. Due to a lack of domestic sources or viable substitutions, requirements for some of these minerals, vital to our national defense and economic growth, will remain a potential point of vulnerability. The challenge is to combine technological and economic feasibility with an internationally acceptable regime that will protect the huge investments required to exploit these resources, while minimizing damage to the ocean habitat.

OUTLOOK

Short-Term Outlook

Steel. Steel production historically follows the economy, so the short-term outlook for steel is good. The impact that the Asian financial and economic crisis will have on domestic steel production remains to be seen, but it is likely to be muted. On average only 17% of US steel imports originate from Asia. Weakened Asian economies may try to expand exports to the US, but additional suppliers will be more likely to take market share from other exporters than American companies.

Aluminum. Short-term outlook is for continued but slow growth, following the industry's sustained 3-5% growth annually over the past 25 years. Growth in alumina and aluminum production is and will continue to be centered primarily in developed nations like the US; bauxite-mining operations will grow primarily in developing countries where the resource is plentiful. Recycled aluminum will continue to occupy a large segment of the industry. Advanced materials will erode market share, but aluminum industry initiatives and the mandate to reduce greenhouse gases may significantly increase the use of lighter weight aluminum to replace more steel in the transportation sector. Aluminum price reduction is key to such a strategy. If such a change does not occur, manufacturers may opt to move on to use the next generation of advanced materials.

Advanced Ceramics. Advanced ceramics technology is poised to accelerate its penetration in commercial and military systems after nearly 50 years of promising but limited successes. Detroit Diesel has

announced an all-ceramic valve system that will be widely deployed, potentially in millions of engines. Several auto manufacturers are using advanced ceramic seals in water pumps. Machinery producers are employing ceramic bearings to cut maintenance costs dramatically. The C-17 and late model C-130s employ armor made of advanced ceramics. The Joint Strike Fighter will employ advanced ceramics to boost power and reduce weight.

Composites. The US leads the world's research in areas aimed at reducing the high costs associated with the manufacturing and repair of composite components (Fink). The goal is to move away from the big expensive autoclaves, which traditionally provided the best quality, and into much lower cost options. DoD and industry have made steady progress in developing composite repair equipment and procedures. Since 1987 McDonnell Douglas, Boeing, and other companies have been developing and improving repair procedures for systems such as the Army's High Mobility Multipurpose Wheeled Vehicle (HMMWV) (Repair Methods) and the Air Force's F-117 (F-117 Composites Structures).

Long-Term Outlook

Steel. A vital material such as steel is not going away anytime soon. Over 90% of all metal consumed in the world is steel. Advanced materials will, however, gradually eat into steel applications, especially in certain niche uses, but the cheap cost of steel should remain a powerful countering force. Domestic integrated steel-making capacity will probably continue to remain nearly static because of the industry's need to continue shouldering the "legacy costs" of earlier production times, which mainly involve substantial pension fund payments. The more efficient mini-mills should continue to compete effectively with foreign suppliers for the other half of the US market. Only after the debts of the earlier years are paid, will the US integrated steel industry be able to expand. No matter what, there is sufficient worldwide steel capacity to meet US strategic needs.

Aluminum. The aluminum industry will require significant investment in R&D to address a number of concerns. The first is to increase efficiency and thus competitiveness relative to alternative materials. Second is to reduce emissions to comply with Kyoto Accord requirements. Third is reduction in the cost of energy to reduce aluminum prices. Fourth is to develop technologies that may increase the use of aluminum in all applications such as manufacturing, welding, painting, etc.

The Aluminum Technology Roadmap recognizes the importance of each of these concerns. We should see sustained long-term growth if the aluminum industry invests R&D dollars wisely and benefits from efficiencies. If, however, industry focuses on short-term profits over long term capabilities (like the US steel industry did during the 1950s, 1960s and 1970s), the aluminum industry will be hard-pressed to compete with new and emerging technologies.

Advanced Ceramics. With the end of the Cold War, defense funding of advanced ceramics application has been reduced significantly. However, the high capabilities inherent in advanced ceramics will continue to be recognized, but funding will undoubtedly be stretched out over a longer period, more linked with commercial applications.

Composites. Just 6 years ago, a total of 22.5 million pounds of composite fibers found their way into all manner of products. By 2007, industry experts estimate composite fiber use will top 200 million pounds annually (Graham). As manufacturers continue to reduce the cost, improve mass production techniques, and resolve reparability issues, we can expect to see a rapidly growing composite presence, particularly in the defense and construction industries. With composite "smart materials" (embedded sensors in a composite structure) that sense the environment and transmits stimuli to piezoelectric devices are now possible. These signals cause the composite material to contract or relax, simulating what occurs in animal muscle action. Hence, the designation "smart materials"(Robinson). A version of this technology is under development in the vibration monitoring and self-correction capability of next generation Army helicopter rotors. Similar advances are expected in the use of smart materials for roadways and bridges, transmitting signals about materials fatigue and other dangers (Jacobson, p. 3).

GOVERNMENT GOALS AND ROLE

The role of governments in traditional and advanced strategic materials industries range across the globe from a central planning approach to a laissez-faire approach where most decisions are made by the market. The US government has historically been most comfortable somewhere closer to a hands-off approach. This approach is particularly applicable in the current peacetime environment. In the US, central planning has been introduced during times of national emergency or war.

United States

The US imports strategic minerals such as chromium, cobalt, manganese, and platinum because of a lack of domestic sources. This fact drives certain US goals and policies, even if implicitly rather than explicitly. US policy has been to obtain adequate mineral supplies at the lowest possible cost, taking into account the interests of allies (Hodges, 1995). This is essentially a laissez-faire free market approach (Hodges). This approach is based on ample short-term supplies of strategic minerals and the premise that third world exporters of strategic materials have no immediate alternative to supplying the large US market. As Hodges (1995) summarized, "concerns about self sufficiency and minerals security of the US are no longer overriding." Lack of strong interest in ratifying the 1982 Law of the Sea Convention, which covers deep seabed mining, also demonstrates the US government's hands-off approach.

In manufactured goods made with composites and ceramics, however, there is US government and private sector efforts to support R&D. Composites and ceramics have clear linkages to national security because of their applications across the defense spectrum from aerospace to telecommunications to undersea use. Composites and ceramics also have dual use private sector applications. However, there is a disturbing trend of declining funding for R&D.

Current US Government Role. The US applied lessons learned from World War II (WWII) during the cold war to ensure strategic materials such as chromium, cobalt, manganese and platinum were stockpiled so that they would be available for the next war. Competition with the Soviet Union helped drive the engine of weapon systems and advanced materials development. Today this approach is being abandoned somewhat haphazardly mainly because no perceived threat exists that drives the US to stockpile. For similar reasons, weapons systems procurement is in decline, so strategic materials development has begun to slow noticeably.

As a result of this policy shift, US government research funding for strategic materials is declining with the apparent goal of allowing the private sector to fund a larger share of future R&D. This approach appears "smart" from a cost savings point of view, but it contains risks. The biggest risk lies in the fact that most private industrial enterprises are reluctant to engage in mid- to long-term R&D because publicly-owned businesses tend to operate with a short-term focus on profits. The long-term interests of the nation are not often served by focus on short-term interests of private enterprise.

Another weakness in this reduced funding approach is that many R&D efforts require more funding than the private sector can afford. The space program and nuclear power are two historical examples of national efforts that private industry arguable could not have achieved without substantial government funding. No private sector materials research efforts were observed that began to approach the work being done at the Naval Research Laboratory in Washington, DC. Government-funded laboratories are national treasures that should be very carefully examined before irreparable damage occurs as a result of underfunding.

Roles the US Government Should Play. The US government should avoid the temptation of allowing the pendulum to swing too far in the laissez-faire direction. The government needs to be a player in the materials industry. This will ensure the country's maintenance of military superiority and will invigorate our global economic competitiveness.

Government's role should include a recurring advisory mechanism by which the nation's vital or strategic materials are defined and evaluated. Strategic vulnerabilities or shortcomings should be identified and addressed. From this mechanism should spring the planning and development of a strategic vision and roadmap for preserving national security and economic prosperity. This vision should include government partnership with industry to promote R&D in both traditional and strategic materials. This role should focus on mid- and long-term national and security application because of the growing tendencies of US industries to focus only on shorter-term profit motives. The government needs to encourage, through incentives, private sector R&D on materials with mid- and long-term benefits.

The government possesses other responsibilities. There must be a level global economic playing field for US materials companies. Access must remain open to domestic and international sources of both raw and finished materials. Finally, the government must remain vigilant to problems and prepared to act in those cases where market dynamics fail to ensure attainment of US strategic materials objectives.

Canada

Canada is a net exporter of strategic minerals, a significant difference from the US. Thus, Canadian goals are oriented more towards maintaining international competitiveness while enhancing the domestic economy. Canada also has relatively healthy steel and aluminum industries. Of note, 15% of all steel imported by the US comes from Canada.

Canada supports a limited amount of materials R&D at universities and government laboratories. It is at the leading edge in some fields. Overall, however, lack of emphasis in materials research at the university level has resulted in degradation of metallurgy and materials departments. Canada frequently appears to rely on the R&D efforts of others, often the US. As a smaller actor on the world scene, Canada generally takes a more internationalist approach, supporting international agreements more than the US does as a means of achieving national goals.

Hungary

Hungary's materials industrial activity is comparatively rudimentary. The period following the fall of the Iron Curtain saw the collapse of about one third of Hungary's steel industry. Consequently, Hungarian steel is now the third smallest industry in all of Europe, ranking ahead of only Albania and Switzerland. Fifty-six percent of Hungarian steel is also privatized, primarily through foreign investment. The eastern part of the country still suffers 35% unemployment because of the state of this industry. The aluminum industry, which relied on subsidized energy and alumina from the Soviet Union, has all but disappeared.

One advanced materials manufacturing concern was identified. Zoltek, an US-based composites manufacturer, operates a carbon fiber production facility northwest of Budapest. This facility houses carbon fiber manufacturing equipment identical to Zoltek's Abilene, Texas plant. In addition, Zoltek is attempting at this Hungarian site to cheaply produce acrylic fiber precursor material, which now must be obtained from the United Kingdom. The success of this venture will determine whether significant reductions in carbon fiber costs will be achievable. Such cost reductions are vital to Zoltek's strategic plan to expand its worldwide market share.

Meetings with Hungarian government officials were encouraging. Despite many lingering trappings of a centrally planned economy and a massive communist bureaucracy, Hungary appeared to have an accurate, realistic view of where it stood economically, where it needed to go, and generally how it intended to get there. Future entry into NATO and later, the European Union, are positive in that regard.

Austria

Only one strategic materials industry was observed, Voest-Alpine Stahl or VA Steel, located in the city of Linz. This integrated steel

company enjoys the luxury of being one of the very few mills geographically located near the major European automobile manufacturers Audi, Mercedes-Benz, and BMW. This resulted in a market that provides an exceptionally stable demand base. In addition, VA Steel facilities are relatively modern, state-of-the-art, and they are well maintained and run. The absence of mini-mills within the area has further enhanced VA Steel's competitive position.

Even more impressive than VA Steel was the Voelst Alpine Technology Company (VA Tech), a sister company to VA Steel. VA Tech specializes in the engineering of steel production equipment. Its business is global and includes setup and building, from the ground up, of steel mills in developing countries. Of note, VA Tech provides engineering services for US steel companies.

Government involvement in the Austrian steel industry is significant, though declining. Both VA Steel and VA Tech were completely government owned until 1995. Both companies have been privatized with the Austrian government retaining ownership of approximately one-third share. However, even under their new privatized state, both companies continue to benefit from the original government outlays for capital equipment and labor. In particular, Austria's social security pension system relieves VA Steel of many of the "legacy costs" encountered by US steel companies. Long-term problems could develop for the Austrian steel industry, however. A firmly entrenched pro-labor political base, which pushes full employment, could cause the steel industry to keep its labor force artificially high, resulting in excessive labor costs.

Recommendations

Industrial Policy. As the term is currently understood, the political and economic leaders of the US are clearly not prepared to accept anything that could be called "Industrial Policy." The study group suggests, however, that the government fund some independent analyses (through, perhaps, reactivation of the National Security Advisory Panel on Critical and Strategic Materials) that would explore specific technological fields. These might be areas that, in the years ahead, could be particularly useful in a strategic way, or on the leading edge of rapid growth or more widespread application. The US government should *not* be responsible for selecting or funding specific technological fields or for favoring them in any way; rather, the independent (but government-funded) research would be responsible for disseminating promising research conclusions through the US private sector. It would be up to the

private sector then to make its own decisions for follow-up R&D, practical applications, etc.

Use of the Stockpile. We recommend that the materials stockpile continue being phased down in a gradual, responsible manner. Materials processing and manufacturing, and the entire use of materials, have changed enormously since our mobilization experiences for WWII, Korea, and Vietnam. Where stockpiles may be needed for any protracted war contingency, we recommend that incentives be developed to privatize the stockpile.

Dependence Upon Strategic/Advanced Materials—There is no doubt that our selected use of strategic or advanced materials has provided us the leading edge in many military applications: power, speed, stealth, and survivability have all been enhanced by the use of specialized materials. However, these advantages are not without added costs and risks. These materials, many of them composites, are often more expensive to acquire (usually because of their limited use), more difficult and complex to fabricate, more demanding to work with, and frequently almost impossible to repair. Nevertheless, we believe that the payoff in performance characteristics more than compensates for the problems. If industry does not find it profitable to find ways to lessen or eliminate these problems, we believe it is in the government's interest to do so.

CONCLUSIONS

A fundamental shift in defining strategic materials has occurred over the past 50 years. Subtly changing since the end of WWII, the pace rapidly quickened with the passing of the cold war. Our historic focus revolved around products and materials required for national defense, particularly those held at risk by hostile forces. A globalized economy lends a broader perspective on what should be considered of strategic importance to a nation. Strategic materials now both expand our economy and promote national security. Their spectrum is widely diverse and highly dynamic, ranging from traditional metals, such as steel and aluminum, to emerging composite fiber and ceramic materials. What is of significant strategic importance to one nation may not carry the same emphasis in another, if the raw materials are abundant and processing capability exists within national borders.

The whole of strategic materials is larger than the sum of its parts. The original raw materials are the building blocks on which all else is based. Still, without innovation and technical capabilities to refine this material, there is no development or evolution.

More technologically developed nations, such as the US and Austria, hold a distinct qualitative and quantitative advantage over their less developed neighbors. The engine driving materials development is becoming progressively more market-driven. As has been proven by events of the last decade, governments cannot dictate the direction or pace of economic and technological development as well as the free market. Despite this recognition, conflicting realities emerge within different geographic regions. The European Economic Union is expected to encourage free trading between European member states, but may also emerge as a trading bloc that limits external trade opportunities. In the Western Hemisphere, NAFTA is opening trade between the Americas but is sometimes viewed as threatening by our European trading partners.

Economic forces have other stark realities, particularly regarding investment in R&D. Business must see a clear objective to justify funding material development. Often this objective must be attainable in the short-term to satisfy shareholders with a positive cash flow. This, in turn, creates a clear need for government involvement in long-term R&D, such as that being performed at the Naval Research Laboratory. If basic research progresses to the point of clear commercial or military application, a partnered hand-off to industry offers an opportunity for practical technological improvements. Both government and industry win by employing their relative strengths in the national interest.

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TRANSPORTATION

ABSTRACT

The transportation industry continues to be central to the US economy. The greatest increases in productivity could all be negated if the goods don't get to market.

Individually, the transportation modes cover the nation with a network of air routes, roads and highways, rail, canals and ports, and pipelines. There are advantages and disadvantages related to cost and global and domestic coverage. As such, it is critical that apportionment of funding relates to the anticipated volume of freight throughput at these facilities. Managing congestion, infrastructure upkeep and expansion problems associated with this industry are paramount to any future growth and realization of potential.

The transportation industry can do more to compress time than any other industry, thus satisfying the manufacturer's need to make the product when it's needed. Movement of the right product quantity, at the right time, to the right place will shorten the logistics time line.

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Mr. Charles Wells, Defense Intelligence Agency

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Mr. Jim Tarrant, Dept. of State, faculty

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PLACES VISITED

Domestic

Alameda Corridor Transportation Authority, Long Beach, CA
American Airlines, Fort Worth, TX
American Presidents Line, Port of Los Angeles, CA
Ameritruck, Fort Worth, TX
AMTRAK, Washington, DC
Burlington Northern Santa Fe Railway, Fort Worth, TX
Burlington Northern Santa Fe Railyard, Alliance, TX
CSX Intermodal Rail Facility, Baltimore, MD
Defense Logistics Agency Facility, Memphis, TN
Federal Express, Memphis, TN
Long Beach Port Authority, Long Beach, CA
Maryland Port Authority, Baltimore, MD
Union Pacific Intermodal Container Transfer Facility, Long Beach, CA
United Parcel Service, Burtonsville, MD
US Naval Ship *Antares*, Baltimore, MD

International

Caterpillar Logistics Services, Brussels, Belgium
DHL, Brussels, Belgium
Emery Worldwide, Brussels, Belgium
Sabena Airlines Air Freight Terminal, Brussels, Belgium
US Delegation to the European Union, Brussels, Belgium
US Embassy, Brussels, Belgium
European Transport Systems Division, Moerdijk, Netherlands
Rotterdam Port Authority, Rotterdam, Netherlands
Rotterdam Rail Service Center, Rotterdam, Netherlands
Royal Nedlloyd N.V., Rotterdam, Netherlands
Sea-Land Delta Terminal, Rotterdam, Netherlands
598th Transportation Group, US Army Military Traffic Management
Command, Rotterdam, Netherlands
Van der Vlist Special Transportation, Groot-Ammers, Netherlands
Baltic Exchange, London, UK
British Airport Authority, Heathrow Airport, UK
British Airways, London, UK
EURO-Tunnel, Folkstone, UK / Calais, France
GE SeaCo, London, UK
Maersk Lines, London, UK

INTRODUCTION

The study group set out to investigate and critique an industry that reaches further than any other in its affect on the health of the global economy. This analysis looks at the US and European overarching systems of commodity movers. The study portrays the current situations, including financial and information technology aspects, as the path envisioned for a better transportation network to service future requirements.

The group focuses, in some detail, on the affect that information has and will have on this industry. Transportation's management of information and the associated technology will positively impact the future, allowing for the significant compression of time. This information revolution will lead to the most significant advances in manufacturing efficiency since the invention of the steam engine.

The transportation industry continues to be the glue that holds the US' economic system together. The greatest increase in productivity could be negated if the goods don't get to market. The transportation system brings together all of the elements of national power that make the US a superpower.

Individually the transportation modes cover the nation with a network of air routes, roads and highways, canals and ports, and pipelines. These conduits direct the largest volume of people, goods, services, and material in the world. The US is the model for a global economic system supported by an overarching transportation network, the likes of which the world has never seen.

The key to future planning is a comprehensive vision of needs for the movement of goods, workers, and materials, for the market and for defense requirements. The parochialism that exists in today's planning bodies can't be the model for the next century. One cannot neglect the transportation component of any nation's infrastructure and survive in today's global market.

THE TRANSPORTATION INDUSTRY DEFINED

The US has the largest transportation system in the world. It serves 260 million people and six million business establishments spread over the fourth largest country (landmass) in the world. The sheer physical size of the transportation system is difficult to comprehend. Its four million miles of roads would circle the globe 157 times. Its rail lines would circle the world seven times, and the oil and gas pipelines would

circle it nearly 56 times. In 1995, cars and light trucks were driven 2.2 trillion miles in the US.

The various mediums used for travel are air, maritime, pipeline, rail, trucking, and intermodalism.

Air. Airlift refers to the ability to transport cargo and people from origin to destination effectively and efficiently, in a seamless and coordinated manner.

Maritime (or Sealift). It covers the movement of freight and passengers via ocean going sea vessels and inland barges. The movement can be international, intercoastal, or intracoastal.

Pipeline. Used primarily to transport oil and gas in the US although they can also be used to transport anything that takes on a liquid or gaseous form.

Rail. Transport of freight and passengers via intercity railroads. In the US, Class I railroads (those with operating revenues of \$255 million or greater) are the primary freight haulers. AMTRAK is the sole nationwide passenger mover.

Trucking. The principle mode for highway freight transportation.

Intermodalism. The use of more than one mode of shipping to move goods to market. The combination of two or more modes is potentially the most efficient and cost-effective transportation concept. It broadens manufacturing companies' access to areas of the country that otherwise may be inaccessible.

CURRENT CONDITION

Air

Analysts predict the number of new orders for commercial airplanes will increase significantly before the end of the century. Just as more cars means crowded highways, more aircraft will mean crowded skies. To maintain the National Airspace System (NAS) at the level needed to meet expansion, the Federal Aviation Administration (FAA) has planned improvements for communications, automation of traffic management, weather detection and prediction, navigation, and NAS facilities.

The FAA forecasts a 43% increase in the number of commercial aircraft between 1998 and 2008, with an associated 30% increase in domestic airline departures. A critical challenge facing the FAA is to continually increase the levels of safety as the system experiences a growth in demand. Many of the initiatives being proposed today are focused on meeting the demands for more capacity and increased efficiency, and reducing margins of time and space, not safety. Despite

spending over \$25 billion during the last two decades, the FAA's computer modernization programs and resultant system capability have not kept pace with user demand.

The FAA's mission is to ensure the safe and efficient use of airspace; to foster civil aeronautics and air commerce in the US and abroad; and to support US national defense. Some of FAA's major activities include handling aircraft takeoffs and landings, managing en route airspace, conducting aircraft safety inspections, ensuring airport security, providing airport improvements via grants, and operating and maintaining NAS —our "highways in the sky."

Safety issues in particular are ones that the military can address in cooperation with civil aviation. Department of Defense (DoD) has funded programs for Global Positioning System (GPS) configuration and NAS modernization. Under "Free Flight," planes would be free to fly anywhere — not just on airways — in close proximity, avoiding other aircraft and weather while saving time and fuel. Although Free Flight is the ultimate goal and DoD expects to meet full implementation by 2010, the threat of exclusion from airspace looms if schedule or cost changes are encountered.

Maritime

The American maritime industry continues to decline. Without strong maritime infrastructure, viable American coastal and inland markets, sufficient links to other modes of transportation, and legislation that supports competitive advancement of the waterborne transportation industry, America stands to lose ground against nations in all regions of the world. Other nations are setting the conditions to assume maritime trade leadership through investment, trade alliances, and recognition of global trends in waterborne business and commerce. The result is a lack of competitiveness for American flagged ships internationally, higher labor and operating costs for domestic commerce and shipping, and undeveloped market opportunities on American shores that might otherwise be open and part of global commercial expansion and growth. If it remains cost prohibitive to improve ports, develop infrastructure, and pursue domestic commercial opportunity, our nation cannot guarantee global maritime competitiveness.

Pipelines

The first cross-country oil pipeline was laid in Pennsylvania in 1879. When coastal shipping was disrupted in World War II by the threat of

U-boat attacks, long-distance oil and gas pipelines got a boost. Two pipelines were built from the Southwest to the East Coast; one was a 24-inch diameter, 1,250 mile crude oil line and the other was a 1,470 mile, 20-inch diameter petroleum products line. From this simple beginning, oil and gas pipelines have expanded throughout the US so that today about 227,000 miles of pipeline carry crude oil and petroleum products to refineries and markets.

Rail

Railroads have played a major role throughout American history. Their major attributes to the marketplace were those of volume and speed. World events felt their impact almost immediately. National expansion fueled the transcontinental railroad growth.

Early in America's history, the "rail barons" had to buy the land and build the infrastructure themselves. In the late 1860s, the federal government awarded the railroads land for "rights of way" to entice them to construct the transcontinental railroad. The inefficiencies of the industry in the 20th century can be traced to these early days of government intervention.

By the mid-20th century, railroads had faced its first great competition with the development of the national highway system. A short time later, increasingly affordable air travel would affect the rail passenger market. The modern day downward decline of the rail system continued until the Staggers Act of 1980.

Unlike European railroads that are primarily people movers, US railroads today, with the exception of AMTRAK, only transport freight. The US has more area available than Europe to build new rail lines and fewer restrictions to modify infrastructure to operate high double-stack container cars and long container and bulk trains. European rail operators compete with several hundred passenger trains every day for use of the rails, while US railroads, whose focus is moving freight, find the occasional, almost always, faster moving AMTRAK passenger train to be a hindrance.

A Class I railroad, as previously defined, has operating revenue of \$255 million or more. There are 11 Class I railroads, comprising only 2% of the railroads in the US. This 2% accounts for 73% of the rail mileage operated today. Railroads excel at moving bulk cargo long distances. Coal was the railroads' top commodity in 1996, accounting for 43.8% of total tonnage and 22.5% of freight revenue. Farm products, chemicals, and allied products were the second and third largest commodity groups.

Intermodal trailer and container traffic increased in 1996 by 2.7%, demonstrating the potential railroads have in additional markets. With the major Class I railroads now making money, the federal government has sharply reduced its outlays to the rail industry. The Federal Railroad Administration budgets for fiscal years 1997 (\$1050 million), 1998 (\$732 million), and 1999 (\$751 million) each includes a subsidy of more than 85% for AMTRAK. These budgets include \$20 million earmarked each year for general rail system research and development and between \$13-\$25 million each year specifically designated for high-speed rail technology. AMTRAK, by restructuring and recapitalizing, is slowly working its way to become profitable.

Trucking

Before discussing the nation's trucking industry, it is essential to understand the key enabler of the US trucking industry—the nation's roadways. A snapshot of the nation's roadway system shows a physical infrastructure of nearly four million miles of public roads and highways, more than 360,000 interstate trucking companies, 20 million trucks used for business, and 190 million private automobiles.

Domestic manufacturers nearly exclusively use motor carriers for transportation of their goods. Increased use of rail traffic has also resulted in increased less than a trailer load (LTL) and trailer load (TL) usage as a means to provide flexible transportation between rail centers. The diversity of trucking enterprises is staggering, with 423,153 firms identified by the American Trucking Association. Of these firms, 69% have six or fewer trucks and 78% operate 20 or fewer. The Dow Jones Transportation Index has increased nearly 6.8% over the last year and quarterly profits have increased with most small carriers averaging nearly 3% (American Trucking Association).

Three principal issues face the trucking industry's continued success. Safety is a dominant interest, driven by the public's concern for personal safety while on the roadways. American truckers are concerned that with the passage of the North American Free Trade Agreement (NAFTA) that their progress in roadway safety will be eroded.

A second issue facing the industry is the mounting pressure to increase taxes. Trucking pays \$25 billion per year in federal and state roadway taxes. In addition, they pay \$11 billion annually through the federal diesel fuel tax (24.4%). With the greatest threat to continued roadway improvement coming from funding shortfalls, pressure is mounting to increase user fees for those who use the roadways for commercial gain.

The third issue involves erosion of the roadway infrastructure— the “life blood” of the nation’s trucking industry. Surveys indicate that 28% of the roads are in poor condition and that 32% of the bridges are considered deficient (American Trucking Association). Trucking firms see critical roadway funding being diverted from interstate projects to local routes as crucial to their future prosperity. Legislation providing \$168 billion for highway improvements was proposed to the President in early 1998.

The US trucking industry enjoys a distinct advantage over European firms. Deregulation and greater cooperation between states provide domestic carriers with a “near-seamless” network across the country. Recent NAFTA developments offer the same potential opportunity for an effective network throughout North America. Although the European Union provides many advantages, individual countries continue to haggle over permit requirements and tax restrictions regarding the trucking industry.

Population growth and its associated automobile growth have placed greater demands upon the European environment. This fact is creating the forum for additional restrictions on the European trucking industry. Restrictions include such things as prohibiting weekend truck movement, restricting rush hour and daylight trucking, limiting weight capacity so roads and bridges are not over-stressed, and length restrictions to negotiate some of the narrower and winding roads. Additional pressures may force shippers to go to alternative transportation modes, such as rail or barge to overcome the reliability risks associated with additional restrictions.

Intermodal

The US has experienced a downward trend in the shipbuilding business. However, container transport and the intermodal link with ships, ports, rail, and trucking make the US intermodal network one of the most far reaching in the world.

The US initially owed its prosperity to a worldwide oceangoing fleet of vessels, arguably having few peers on the high seas. Today however, the US fleet of oceangoing commerce vessels ranks well down the list of seafaring nations. The US is still loading or offloading more cargo than it moved in the past; however, a growing number of these ships are foreign container ships. The good news is that these ships still reach US ports and offload containers into the US intermodal system. This prompts emphasis on the infrastructure to support the docks, truck trailers, and rail cars for distribution systems throughout the US.

Intermodal containers come in an increasing variety of shapes and sizes, ranging up to 53 feet long if used only domestically in the US. Several alliances and mergers have dramatically changed the complexion of this transportation mode over the past 2 years. The railroad giant CSX owns Sea-Land shipping lines. Sea-Land has an alliance with Maersk shipping lines, and when combined, operate one of the five largest shipping networks in the world. P&O/Nedlloyd is also a member of this top five group. In-transit and internal cargo visibility play vital roles in the growth of container usage headed by these firms.

Information Technology

Information technology (IT) is fundamentally transforming the transportation industry. In fact, some observers feel that information is the fifth, and most important, mode of transportation. Current technologies being used include electronic data interchange (EDI), the Internet, GPS tracking, radio frequency identification (RF/ID) tags, and revolutionary bar codes. These are all vital to the transportation industry.

Automatic Identification Technology (AIT). AIT is a suite of technologies that enables the automatic capture of source data enhancing the ability to identify, track, document, and control deploying and redeploying forces, equipment, personnel and cargo for sustenance. AIT also includes the use of satellites to track and redirect shipments. AIT is the enabling technology for total asset visibility. Given its positive results at FedEx, United Parcel Service and DHL, it may be the long-awaited solution to the age-old logistics problem of the right part, at the right place, at the right time.

DoD has pursued a muscular approach to tackling AIT implementation, approving a robust AIT CONOPS (Concept of Operations) and establishing a Joint Total Asset Visibility program office. If DoD vigorously implements the CONOPS there is a great likelihood Total Asset Visibility in DoD will become a reality. However, if we don't impose the discipline laid out in the CONOPS, we can expect to repeat Desert Storm's experience of having to open countless containers in order to figure out what was inside. The Iraqi's gave us time to look. Future opponents aren't likely to be as foolish.

GPS Tracking. GPS applications used in vehicle tracking have been growing at a 30% rate annually, representing 16% of all GPS units sold. Only maritime applications, at 17%, have a larger market share.

Radio Frequency Identification (RF/ID) Tags. RF/ID systems can be viewed as electronic labels that contain an integrated memory module, radio transmitter/receiver, and antenna. Perhaps the most successful of

all current RF/ID applications is vehicle identification. The rail industry is using the technology to increase the visibility of rail and intermodal shipments. Individual item tracking within pallet loads may become the next significant concept in RF/ID technology. The benefits are clear, since it will provide accurate content information to partners in the supply chain.

Government Use of Information Technology

DoD is trying to increase the use of EDI technologies in the transportation area, especially since many commercial carriers are anxious to use it with DoD.

Premium Service. Through a partnership established with FedEx in 1994, Defense Logistics Agency (DLA) offers DoD customers a fast, reliable, and service-oriented distribution channel. This unique arrangement allows critical high-priority items to be delivered within 24 to 48 hours, 7 days per week. Because the DLA Premium Service warehouse is located at FedEx's hub in Memphis, requisitions can be received up to midnight with continental US delivery guaranteed the next day. Requisitions for the 3,200 stocked items can be received on-line via MILSTRIP or the Internet.

Enhanced Vendor Delivery (EVD). EVD is another concept DLA has introduced. First, DLA establishes an order with a supplier or manufacturer. The order is priced on an origin basis with all transportation costs initially paid by the government's selected third-party logistics manager. Second, the manufacturer notifies the third-party manager when the item is ready. Third, the manager selects the shipment mode and carrier based on the requirement's priority and negotiates transportation rates. While the item is in transit, the manager tracks it from pickup to delivery and provides in-transit visibility (ITV) information to inventory, transportation, and other logistics systems.

Bar coding, radio communications, computers and systems combine to solve ITV problems. An entire industry of third-party logisticians has emerged to provide expert handling, shipping, and tracking of materials. EVD allows contract arrangements with logistics managers to distribute items from vendors to distribution depots, end users or repair contractors.

RF/ID Technology. As part of the Total Asset Visibility initiative, DoD recently made the largest single investment ever in RF/ID technology. Signing a \$111 million contract with Savi Technology, DoD will use more than 150 commercial-off-the-shelf (COTS) RF/ID products with software that provides a single interface throughout the system. This project demonstrates DoD's interest in using COTS technologies for

logistics applications, since many commercial distribution firms currently use the hardware and software.

Joint Total Asset Visibility (JTAV). Through its interface with the Global Transportation Network (GTN), JTAV provides in transit visibility of assets throughout the distribution pipeline. Additionally, it leverages the capability of emerging AITs, from bar codes to smart cards and RF/ID tags to GPS systems, facilitating supply chain visibility. JTAV will provide users an improved capability to act on information.

CHALLENGES

Rail

The rail industry faces a variety of inefficiencies that result from a long history of government intervention and control. Passenger rail in this country would be outdated without the heavy subsidy that the federal government provides to AMTRAK. The movement of freight could face the same dismal future if the government doesn't take an active role in fostering efficiencies in the industry, such as unrestricted use of competitors' track and moving each others' cars.

In Europe, with its greater population densities, passenger trains operate around the clock, greatly reducing highway and air congestion. The EUROSTAR train—operating between Brussels and London and between Paris and London—using routes via the newly constructed EURO Tunnel, has greatly reduced air traffic between those cities. The US is beginning to encounter the highway and skyway congestion challenges present in Europe and must develop a viable, all weather alternative for transporting people. The world's industrialized countries enjoy an abundance of oil that is stimulating their economies. However, fuel quantities will certainly not increase in the future, thus fuel prices at best will remain stable or more likely increase over the next 50 years. As this occurs, air and highway travel will increasingly become more expensive, making rail the economic mode of choice for transporting people.

Shippers believe that cargo can be moved by truck economically up to 500 miles compared to rail transportation. Intermodalism's growth has magnified urban congestion on highways in and around ports in America. The ports of Los Angeles and Long Beach are quickly reaching the point of gridlock. The construction of the Alameda Corridor Project has begun to relieve the congestion caused by the movement of containers from dock to railhead via truck. Trucks moving containers in and around the city is a certainty. However, if railroad efficiencies could

be maximized (cut off point reduced to 300 miles), the trucking and rail industry would benefit. Additionally, America would benefit from reduced highway congestion and air pollution, improved fuel efficiency and highway safety, and more competitive pricing.

Intermodalism

Ships, for the most part, are using the major seaports on the coast instead of those further inland. The industry as a whole appears poised to go to a "hub and spoke system," which is very similar to the way the airlines and express delivery service providers operate. Large ships offload and onload their cargo at one regional port, while smaller ships shuttle the cargo to and from other ports in the region. By using the larger ships for servicing the regional ports, they are free to capitalize on what they do best —move large quantities of cargo long distances. The time spent by large ships traveling up inland waterways (e.g. Chesapeake Bay) for several hundred miles is too costly. In addition to the cost of time expended by large vessels are the high costs associated with dredging inland ports.

The increase in shipping to this country means demand for dockage will increase in the coastal ports. This is almost an unsolvable problem. Large ships use of US dock space is rapidly approaching the maximum available. The industry must explore new avenues for receiving cargo.

Another problem is the distribution of goods once they arrive at coastal cities. Distributing the cargo that has arrived at US ports in an efficient manner requires using the deteriorating infrastructure. Yet, the railways in the US are inadequate to support efficient movement of this cargo to its ultimate destinations because of shrinking revenues and constrained budgets. In some areas of the US, rail companies are unable to double stack containers on railcars because the tunnels and overpasses are too low to allow the added height of the double stack. In other regions, delays occur when cars can't move because there is only one lane of tracks. To remedy this requires improvements in the infrastructure.

Intermodalism in the US is growing at about 3% annually. In the future, more material will be shipped in this manner, thus compounding the problems we are facing today. Intermodalism could reach an annual rate of 10%, especially considering the booming US economy.

Information Technology (IT)

On 1 January 2000, at 12:00 am, computational systems around the world may cease to operate, causing chaos in the world. The federal government must proactively work with industry to prevent a potentially catastrophic event that would have major impacts in air and surface transportation sectors far beyond the year 2000. Other IT problems include systems interoperability and security issues.

Outsourcing Military Transportation

Outsourcing and privatization are two of the primary methods the current administration is using to shift operations and maintenance (O&M) dollars into modernization dollars. O&M traditionally accounts for one third of the defense budget and DoD employs more than 640,000 employees in positions with direct commercial equivalence; thus the potential savings are huge. Overall, more than 14% of DoD's 2.5 million personnel can't be outsourced (those officially classified as combat positions).

According to several estimates, including the Defense Science Board, DoD could save between \$12 billion to \$16 billion per year if it privatizes half to all of the \$140 billion it spends annually on noncombat functions. Though the US military estimates its annual budget at only \$125 billion, it too believes it can contract out half of its noncombat functions to realize annual savings of \$12 billion. Aside from the cost savings from outsourcing, services gain increased flexibility to concentrate on core missions. This outsourcing leads to quicker implementation of best business practices.

The current outsourcing process is ineffective. These are four areas that need to be addressed.

Improve Contracting. The existing process is inefficient and needlessly difficult for outsourcing (*Circular A-76*, Office of Management and Budget). In other words, the contracting should be transparent to the warfighters.

Integrate Commercial Vendors with the Warfighter. Outsourced commercial services need to be integrated into deployments, exercises, and full time training. The services can't expect contractors to be ready to commit to wartime requirements if they lack effective, real world training.

Address the "Will they be there?" issue. Make sure there are clauses in government contracts that spell out military requirements including contractor participation in deployments, exercises, and full time training.

Remedies for Job Displacement Issues. Address the issue of job displacement for government workers as outsourcing government jobs will remain unpalatable to key congressional representatives unless those displaced have other jobs.

OUTLOOK

Best Transportation Business Practices Improve Department of Defense Logistic Functions

Joint Vision 2010, the conceptual framework for America's armed forces to view the future, calls for reduced response times, order and ship times, inventories and right-sizing the logistics footprint. The expectation is that rapid transportation and time-definite delivery will supplant large inventories. A migration from a supply-based to a distribution-based sustainment system brings efficiencies to businesses and obviates the need for large warehousing operations. This system relies on the concept of JTAV, which incorporates a seamless information management capability that replaces the traditional division of the logistics pipeline into wholesale, retail, and in-theater. The services have each adopted a version of reinvented logistics programs: the Air Force's Lean Logistics, Army's Velocity Management, Navy's Expeditionary Logistics, and the Marine Corps' Precision Logistics.

Reliability of delivery and speed are characteristics demanded by industry today. Reducing delivery cost allows a company to price its products competitively. It also allows that company to refocus corporate resources on developing new product lines, research, capital improvements, etc. The reduced delivery costs throughout the transportation industry supports US efforts to remain competitive. Inventory as a percent of Gross Domestic Product (GDP) has declined continuously from 24% in 1983 to 17% in 1994. Logistics as a percent of GDP has declined from 17% in 1983 to 11% in 1992.

Greater reliance on COTS technology may well be the only way that the US can acquire sufficient types and quantities of weapons to ensure military success in the next century. The commercial technology base is already supported by a logistics system that is heavily reliant on rapid transportation and integrated information technology networks to maintain a competitive advantage.

Just-in-time delivery, the use of regional distribution hubs, and an increasing reliance on the transport system as a rolling warehouse have reduced warehouse inventories. Industry is moving from a vertical integration to a horizontal integration—the production supply chain

concept. There is a tremendous market in outsourcing logistics software to support this system. Just as companies have capitalized tailor-made vehicle and cargo tracking systems to gain a competitive edge, they are now tailoring product supply chains to sustain that competitive edge.

Implicit in the discussion on trends toward horizontal integration and supply chains is the dependence of these concepts on information management and information technology. There is an apparent need for bidirectional information flow through the supply chain that links the customer with the supplier and intermediaries in the chain. Automated ordering, billing, and electronic payment all rely on an information infrastructure that meets interoperability and security requirements.

Air

The centerpiece of today's efforts is GPS—a system of 24 satellites orbiting the earth at 11,000 miles, providing position accuracies of less than 1 meter for military users through an encrypted signal. In 1996, President Clinton announced that the US would make precise GPS publicly available by the year 2000. Implementation issues have since caused the estimate to be adjusted to 2006.

“Differential GPS” is possible using ground stations to convert precise military signals into a commercial version that would be less precise than the military version, but more accurate than currently available commercial GPS. Properly configured aircraft could participate in Free Flight using “differential GPS.” With the increased accuracy and protective zone or bubble around each aircraft, differential GPS would also be useable for airport instrument weather approaches.

Changes in global civil architecture will also necessitate changes in military equipment and procedures. DoD operates 15,000 aircraft, all of which will be affected by changes in airspace architecture over the next 15 years.

Civil Reserve Air Fleet (CRAF) is the aircraft mobilization program created and used to enable the US to maintain at the lowest possible cost, in peace and war, its international involvement and leadership. This program provides the necessary additional strategic airlift in time of war. Through economic incentives, it provides lower cost peacetime airlift, while enhancing services' quality for the military. This large peacetime airlift requirement is a great economic opportunity for the commercial airline industry.

Three stages of incremental activation allow US Transportation Command (TRANSCOM), with Secretary of Defense approval, to tailor an airforce airlift suitable for a given contingency. Stage I is for a minor

regional crisis; stage II is for a major regional crisis; and stage III, which has never been activated, is for use in cases of national mobilization. When an airline company commits itself to CRAF activation, it must commit its aircraft, four aircrews per aircraft, its terminal and loading facilities, equipment and ongoing maintenance services.

DoD awards peacetime airlift contracts to those companies willing to take part in the CRAF program; this provides incentives to participate in the program and helps meet the military's ongoing needs for the military. According to TRANSCOM, those contracts reached \$617.7 million for FY 1997.

Some CRAF air carriers that participated in Operation Desert Storm in 1990 claim they lost market share when DoD no longer required their services. Although this hurts the commercial CRAF arrangement, the higher prices DoD pays for the city pair agreements with the CRAF carriers harms taxpayers because the fees are higher than the cheapest fare available to the public. In this context, CRAF should be viewed as an insurance policy. Higher peacetime fare prices are the premium for future aircraft availability.

Maritime

Any study of maritime issues would be inadequate without first looking at current and future trends and their implications to assess the extent of the problem for the nation. Several indicators suggest why maritime transportation is critical to the commercial success of our nation.

- Ninety-five percent of all foreign trade uses US ports as its gateway; US foreign trade equals one-fifth of the US GDP.
- NAFTA adds significantly to freight volumes and to trucking's share of the total, since trucking dominates cross-border freight traffic.
- Increased international trade, from NAFTA and other trade agreements, is increasing the demand for containerized and intermodal shipments. However, current intermodal movements are restricted by the capacity of existing infrastructure, both at ports and at inland intermodal facilities.
- The top three trading partners of the US are Canada, Japan, and Mexico. They cumulatively accounted for over 40% of total US trade revenues between 1991 and 1996. While NAFTA favors ground modes of transportation we share with Canada and Mexico, port improvements must clearly be synchronized with our nation's economic prosperity objectives.

In short, while trends through the first few years of the new century may favor road and rail modes, the US must position itself for the coming avalanche of trade expected from regions beyond our shores. A flexible and forward reaching strategic economic plan must include maritime interests ready to trade competitively in the 21st century.

Maritime issues for National Defense

Strategic lift capability is the one bright spot in maritime transportation capability. American Merchant Marine suffers from years of slowly diminishing capacity, and it is smaller today than it has ever been in our nation's modern history. The issue is how large American Merchant Marine needs to be to guarantee a viable response to a national emergency.

Today, there are 33 ships in the Military Sealift Command's Strategic Sealift Force. These are government owned and privately chartered and are used to transport DoD cargo. There are another 93 Ready Reserve Force ships maintained by the US Maritime Administration (MARAD) to provide additional sealift (roll-on /roll-off, breakbulk, and other transport ships). These are reserves that can be activated in 4 to 30 days in case of a national emergency. The Voluntary Intermodal Sealift Agreement (VISA) contractually obligates additional commercial shipping to respond to national emergencies in return for considerable up-front compensation. These ships will make a significant contribution to our nation's defense in times of crisis.

Pipeline Issues for National Defense

While US demand for petroleum products is projected to rise 1.2% in 1998, to an average of 18.8 million barrels per day (bpd), natural gas consumption is expected to rise 1.6% to a record 22.24 trillion cubic feet. This will create a demand for increased import of petroleum products since domestic production is expected to decline 0.8% this year to an average of 6.35 million bpd. US production has declined since 1985 except for a brief increase in 1991 related to the Persian Gulf War. US refineries are expected to operate at close to capacity rates although these rates will decline from 94.4% to 94.2%. With utilization rates so close to capacity, the US product supply is vulnerable to unforeseen refinery shutdowns.

To meet this demand, the pipeline industry requires upgraded information systems to process all of the incoming order data quickly and efficiently; to match it with known orders and current requirements; and to determine excess capacity available for use. Companies that are able to do this effectively will be able to achieve the maximum profit while charging their customers a fair price for the pipeline services rendered.

Trucking Issues for National Defense

The trucking industry appears well postured to support US national security and economic interests into the next century. Deregulation has developed a more efficient system resulting in substantial real price reduction. This trend is expected to continue as fully integrated, multimodal networks operating at near capacity, develop still better methods and procedures to enhance their business.

Other trends indicate increases in regional alignment that will focus upon the specific business activities of each region. Specialization will increase (i.e. flatbeds, tank trucks, bulk carriers) and scheduling will transition to a "time-certain" versus "just-in-time" approach. These specialists will be complemented with a group of TL companies that can move freight regionally or nationally.

Evidence also suggests that the industry is evolving toward shippers relying more on third party logistics. These third party logisticians will handle inventory control and distribution, flow control, transportation, and shipment monitoring. Technological advances will allow real-time transportation and distribution management which means greater automated features for the trucking industry. In addition, third party logisticians' reliance on technology will ensure market discipline in the trucking industry.

The government will retain its central role in tracking and ensuring safety compliance. Automated vehicle inspection systems, early warning crash avoidance systems, and driver monitoring devices are all becoming a reality which will continue to increase the margin of safety among motor carriers.

Advanced technologies will also result in a more accurate assignment of user fees. Systems will be developed to identify carriers that benefit most from public roadways and then accurately charge them for their usage. Environmental considerations are likely to result in the further use of truck-only lanes through populated corridors to minimize the mixing of passenger cars and trucks on the roadway.

An increasing demand caused by international and domestic trade suggests that the trucking industry has solid financial prospects. In particular, NAFTA's increase in north-south trade will significantly add to freight volume. Increased containerized and intermodal movements will offer more opportunities for truck and rail. As offshore shipping increases, the demand for container transportation to and from distribution points will increase. The rapid growth in air freight and rail intermodal shipping will take some of trucking's freight volume, but the majority of it will remain in the trucking sector. Industry predictions project that over-the-road tractors and trucks (above 19,500 pounds) will increase by 13% over the next decade and that its mileage will grow by 27%.

GOVERNMENT GOALS AND ROLE

Joint Vision 2010 considers defense of the US homeland as the number one issue that will ensure the US' future. The report of the National Defense Panel addressed the idea as follows: "We can safely assume that future adversaries will have learned from the Gulf War. It is likely that they will find new ways to challenge our interests, our forces, and our citizens. They will seek to disable the underlying structures that enable our military operations. Forward Bases and forward-deployed forces will likely be challenged and coalition partners coerced. Critical modes that enable communication, **Transportation**, deployment and other **means of power projection** will be vulnerable." Unlike any time in the past 100 years, a domestic national emergency will require the military to depend on a domestic transportation system. Unless we rethink our fiscal commitment to this transportation system, we may find it less than adequate to respond to future national security requirements.

The American Society of Civil Engineers' 1998 report card for American infrastructure graded all of the transportation sectors low. The US is long overdue for upgrades to its transportation infrastructure.

The role of political partisanship in the transportation industry's problems is the single most dangerous issue. Although transportation is only 11% of the US GDP, it is the foundation of the rest of the economy. With the exception of information, everything moves via transportation nodes or networks.

Legislation

The federal government's transportation regulatory method varies from mode to mode. Air transportation was deregulated in the late

1970s with outstanding success in the passenger and the freight business. The trucking and rail industries were deregulated from 1979-1983. The deregulation brought about better rates and fares for the US economy's public sector. The Jones Act continues to control key aspects of sea transportation. This act states that a ship departing a US port for a US port must have a US crew, ownership, and registry in the US to land again in the US for a commercial purpose. Essentially, an entire spectrum of US commerce is artificially supported by legislation that protects it from foreign competition.

Each transportation mode has specific advantages. The series of federally and state constructed roads gives trucking nearly unlimited access to all parts of the contiguous US. Congress has greatly assisted this mode with the numerous highway bills so popular in today's legislative world. The other modes are not nearly as beneficial in their ability to spread tax dollars. Airports, ports and pipelines do not receive the same level of funding that the trucking industry enjoys. This myopic strategy of highway construction at the expense of other modes is a strategy that will become far too expensive in the future.

Intermodal Surface Transportation Efficiency Act (ISTEA)

ISTEA, Public Law 102-240, signed December 18, 1991, considers all modes of transportation "intermodal" (by the very essence of the title) implying movement between modes. ISTEA decentralized the expenditure of the transportation funds—state and local governments had a choice of how the funds would be spent. ISTEA is important to the US because it has changed the transportation's way of doing business. However, ISTEA did not address creating a National Intermodal Transportation System, the original intent of the act. ISTEA legislation expired in May 1998, and a new bill worth \$206 billion is awaiting signature.

Maritime

ISTEA, and its reauthorization legislation, National Economics Crossroads Transportation Efficiency Act (NEXTEA), are void of freight-based components that would foster the growth of the maritime transportation sector and its linkages to other transportation modes. One General Accounting Office account indicates that freight projects account for less than 1% of the total highway and nontransit infrastructure money apportioned to states during the first 4 years of ISTEA. This seems to be inadequate support for a facet of the economy

that in 1994 generated 15.9 million jobs, contributed \$783 billion to the GDP, and provided \$210 billion in taxes.

Revenues notwithstanding, the US still feels the need to protect the maritime industry despite the deregulation trends that have made the air traffic and highway industries so profitable. The US has a history of protectionist legislation that is frequently argued in two contrasting directions. Pro-protectionists argue that foreign governments are protecting their merchant marine industries—why shouldn't we? Opponents state that subsidies and other protectionist methods perpetuate inefficiency and artificially sustain noncompetitive ventures that cannot exist on their own. The primary piece of legislation at issue is the Jones Act.

Opponents to the Jones Act argue that the act originated at a time when railroad monopolies were vulnerable to waterborne foreign competition and the act was originally intended to curtail competition with American railroads. Today, however, the Jones Act is more directly linked to the decline of the merchant marine and the associated diminished markets. For instance, American shipping servicing domestic ports is at its all time low—126 ships (of over 1000 tons) compared to over 2500 ships in 1945. All but 33 of these ships are tankers. Barges are the most commonly used vessels in the system with over 20,000 barges traveling the inland waterways.

Jones Act reform is overdue. Legislators should remove all protective measures that inhibit open competition including the restriction on foreign vessel calls to American ports for domestic freight and passenger movement. This can be done without further jeopardizing the American Merchant Marine. With the promise of expanding maritime markets, opportunities will also expand for professional sailors wishing to enter this segment of the economy as it becomes more profitable.

CONCLUSION

ISTEA

ISTEA is a potential improvement in the way general transportation funds are spent. It has ensured local communities and states have sufficient input in formulating their local transportation solutions. ISTEA has improved mass transit in cities like Washington, DC and throughout the US. ISTEA has made a major impact on the general Interstate transportation system of the US. ISTEA has funded and improved a few of the ports around the US such as Los Angeles and Long Beach. It has worked and improved the connectivity in major

cities such as Seattle and Norfolk. In spite of the previously noted small successes, ISTEA has not had near the impact on furthering the development of the intermodal system as the bill was intended. As an authorization bill for intermodalism, ISTEA does not accomplish its implied mission.

Recommendations

- Transportation trust funds are managed congressionally "on-budget," which allows their funding to be spent for reasons other than their intended purpose (maintaining transportation infrastructure). Money can be diverted to meet other budgetary program needs. How is it that in a nation with economic goals as lofty as ours, we can allow critical infrastructure to deteriorate when user fees exist for the expressed purpose of maintaining it? Congress and the President should act immediately to move all the trust funds "off-budget." It could significantly reduce the requirements for the reauthorization of ISTEA.
- Reduce further federal and state regulations (essentially a follow on to the 1980 Staggers Rail Act). Allow the rail industry to seek the most efficient operating methods concerning areas of public interest (e.g., safety, environmental concerns, energy conservation etc.).
- Work within NAFTA to ensure common transportation safety standards with our neighbors.
- Continue to develop, via joint government and industry partnership, a cost effective, high-speed passenger rail service.
- The US Department of Transportation in a cooperative effort with industry invests heavily in research and development. They should consider research in the following areas: Total Asset Visibility, High Speed Rail, and Intelligent Transportation System.
- Invest in development of the smaller inland ports to lessen the burden on the coastal ports. Off load large container ships onto smaller ships or barges, to be moved inland to specific ports for intermodal transfer. The Europeans have embraced the concept of "Short Sea Transport" thus, significantly reducing highway container traffic.
- Exploit the Alameda Corridor model in other coastal ports in large urban areas.

Summary

There is virtually no better way to prepare for the anticipated increase in trade volume in the 21st century than to lay the groundwork now for infrastructure development in our ports and the ports' intermodal links to the interior. As such, it is critical that apportionment of funding relates to the anticipated volume of freight throughput at these facilities. Today freight throughput is not an evaluation factor for project selection under ISTEA and NEXTEA. Only in this way can ports compete with roads and trains for their fair share of the future market. Similarly, only through improving port interfaces—domestic and foreign—can we ensure doors are truly open to competitive markets on a global scale.

This study has addressed many transportation modes and their respective advantages and disadvantages as related to cost and global and domestic coverage. Although viewed as peripheral issues, managing the pollution and infrastructure upkeep or expansion problems associated with this industry are paramount to any future growth and realization of potential inside the industry. The study group was particularly interested in how information and emerging technology would change and improve the transportation industry. Additional requirements will be placed on the industry as manufacturers substitute warehousing for speed of transit. The transportation industry can do more to compress time than any other industry, thus satisfying the manufacturer's need to make the product when it is needed.

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★ U.S. GOVERNMENT PRINTING OFFICE: 1999 - 454 - 121 / 00003